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Jett et al.

[11] **3,871,450**

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[54] **DUAL STRING CIRCULATING VALVE**

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[52] **U.S. Cl.** .... **166/224 R,** 137/595, 166/147, 166/151, 251/62

[51] **Int. Cl.** **E21b 41/00,** E21b 43/14

[58] **Field of Search**.... 166/115, 147, 224 R, 224 A, 166/313, 151, 184, 154, 189; 251/62, 63; 137/594, 595

[56] **References Cited**

UNITED STATES PATENTS

3,115,187	12/1963	Brown	166/313
3,448,803	6/1969	Sizer	166/115
3,467,185	9/1969	Dowden	166/147
3,572,434	3/1971	Ecuer	166/147
3,750,752	8/1973	Mott	166/224 R
3,799,268	3/1974	Cochran	166/313
3,823,778	7/1974	Mott	166/313

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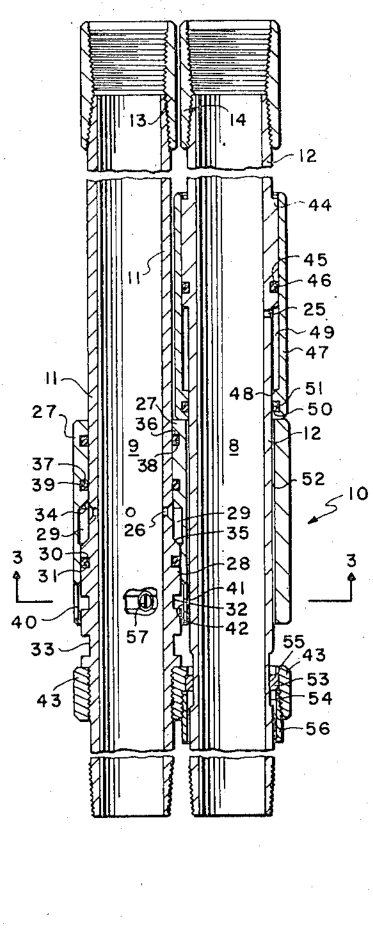
[57] **ABSTRACT**

The dual string circulating valve utilizes a dual-mandrel hydraulically actuated valving system to be used as a circulating valve in a well utilizing dual production strings and is adapted to be inserted in the string below tools like the dual string packer. The valve operates by pressuring one string to open a port through that mandrel to the casing annulus, with closing and locking of the port being accomplished by pressurizing the other string.

20 Claims, 7 Drawing Figures



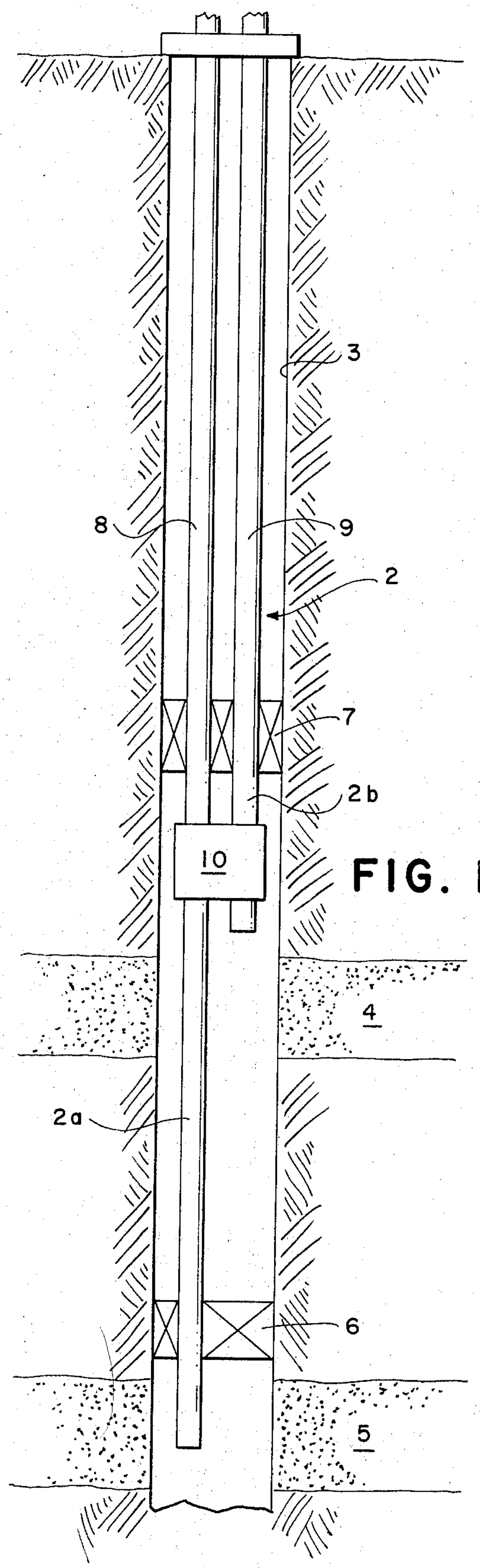


FIG. 1

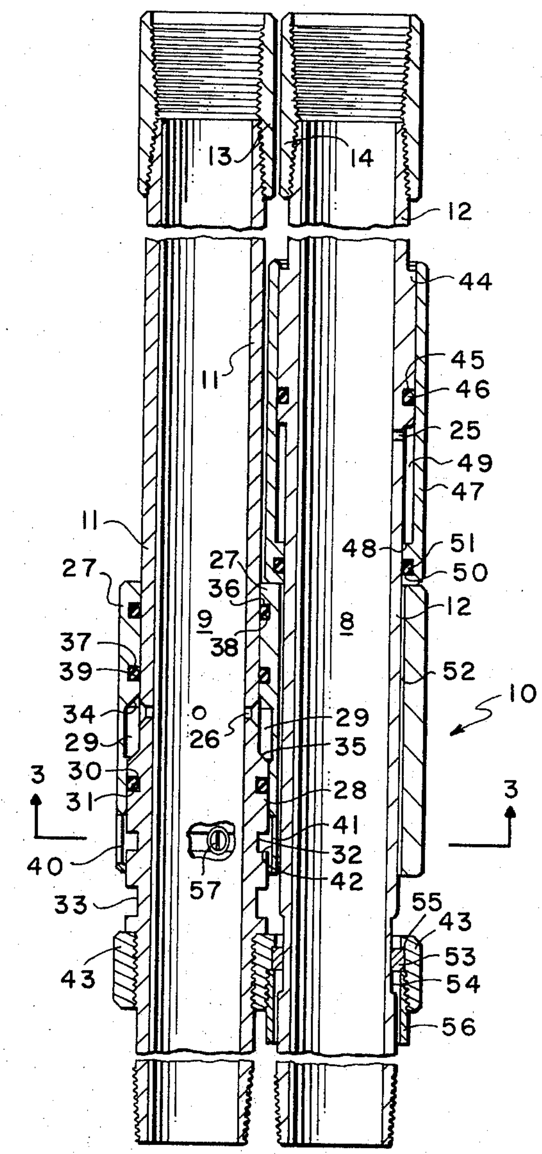


FIG. 2

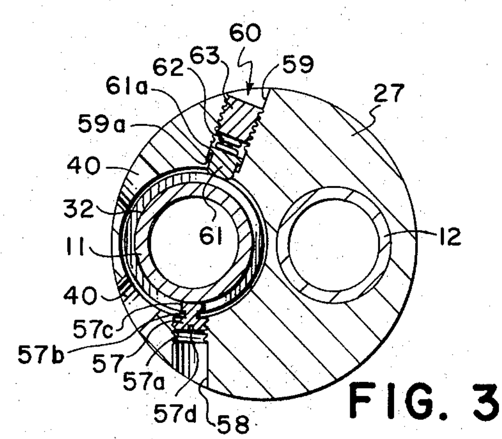


FIG. 3

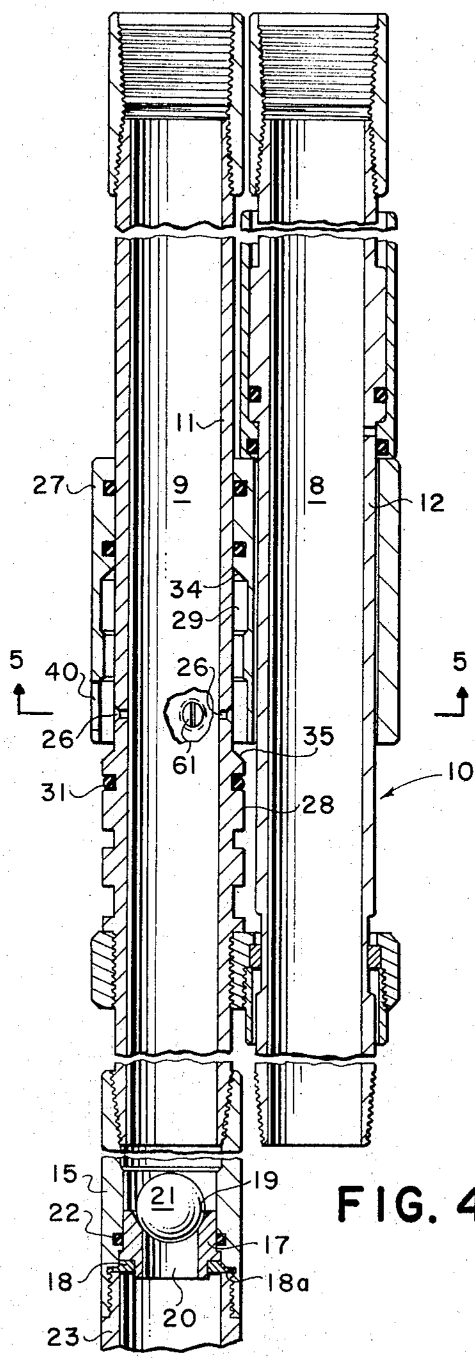


FIG. 4

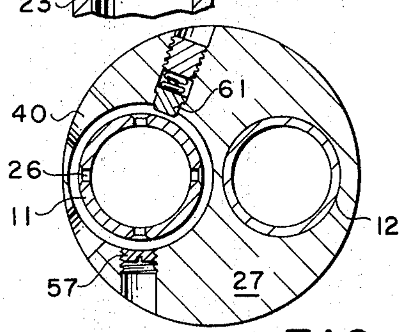


FIG. 5

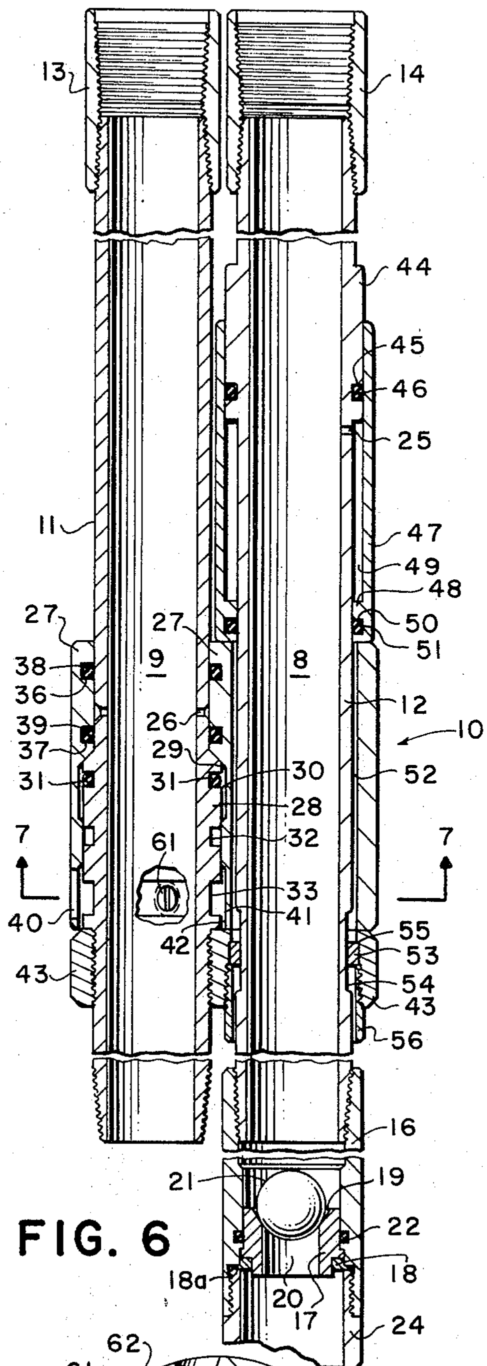


FIG. 6

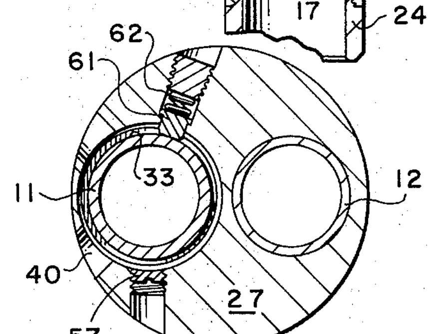


FIG. 7

DUAL STRING CIRCULATING VALVE

BACKGROUND OF THE INVENTION

In the completion and production of multi-zone oil wells and particularly dual-zone wells, a normal procedure for completion is to set a permanent packer in the casing between the producing formations and then lower a dual production string into the well so that one string will stab into the present permanent packer. The dual string will have a dual string packer contained therein which will be located in the string above the top producing formation. Examples of this dual string production packer are disclosed in U.S. Pat. applications Ser. No. 412,221; 412,239; and 412,386; all assigned to the assignee of this invention, and all herein incorporated by reference.

In many wells, particularly those which have been "killed" or which contain heavy displacement fluids, it is advantageous that, prior to the beginning of production, these fluids be circulated or pumped out of the two production strings. This is often accomplished by providing circulating valves in the dual string below the production packer, which valves may be opened to communicate the annulus with the inner bore of the strings so that a fluid pressure can be applied to the annulus fluid at the surface to displace it downward in the annulus and upward out of the production strings.

This requires the displacement to be achieved prior to setting the production packer in order that the annulus will remain open between the surface and the circulating valves. Furthermore, this also requires physical manipulation of the strings to open and close the circulating valves. This manipulation also requires that the production packer remain unset during the operation of the circulating valves so that the tubing can be moved up and down.

This is undesirable in many circumstances because of the danger involved in a possible blowout while the production packer is unset, the heavy displacement mud is being removed, and the tubing is being moved upward or downward. All of these conditions are undesirable and may tend to increase the danger of a possible well blowout.

Another type of circulating tool available is dependent upon the operation of the packer and is only activated by setting of the production packer.

This invention provides a dual string, hydraulically operated circulating valve to be used with a dual string production packer, which circulating valve is actuated independently of the packer operation and without requiring manipulation of the tubing string.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic cross-sectional view of a dual zone production formation having a dual production string;

FIG. **2** is a cross-sectional side view of the dual string circulating valve going in the hole;

FIG. **3** is an end cross-sectional view of the tool taken at line **3–3** of FIG. **2**;

FIG. **4** is a cross-sectional side view of the tool after it has been actuated in the first or open stage;

FIG. **5** is an end cross-sectional view of the tool of FIG. **4** taken at line **5–5**;

FIG. **6** is a cross-sectional side view of the dual circulating valve in its closed orientation;

FIG. **7** is an end cross-sectional view taken at line **7–7** of FIG. **6**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. **1** the dual circulating valve **10** of this invention is shown in place in a dual production string **2** located in a well bore **3** having two producing formations **4** and **5**. A permanent packer **6** was set in the well bore prior to the insertion of the dual string **2** in the well. The long string **2*a*** was "stabbed" into the permanent packer **6** upon placing the dual string **2** in the well. Packer **6** is located between the producing formations to isolate them from each other.

A dual production packer **7** was placed in the string before inserting in the well, and was located in the string so that it would be positioned above the upper producing formation **4**. The dual packer **7** has a long string **2*a*** extending through the permanent packer **6** and a short string **2*b*** extending into the annulus between the permanent packer **6** and the dual packer **7**.

The circulating valve **10** is located in the production string in the borehole below the dual packer **7**. There are two bore passages **8** and **9** extending through the production string and continued through the dual circulating valve.

Referring to FIGS. **2** and **3**, the valve **10** has an elongated tubular primary mandrel **11** and an elongated tubular secondary mandrel **12** arranged substantially in parallel orientation and coaxially aligned with the conduit of the dual production string. The two mandrels have upper adapter collars **13** and **14** threadedly attached thereto for connection into the production string.

Valve collars **15** and **16** are threadedly attached to the lower ends of mandrels **11** and **12** respectively. Each valve collar has a valve seating sleeve **17** frangibly held concentrically therein by shear ring **18**. Each sleeve **17** has a bevelled valve seat **19** at its upper end around an inner bore **20**, said seat adapted to sealingly receive a valve member **21**. O-ring seals **22** pass circumferentially around each sleeve **17** to provide a fluid tight seal between sleeves **17** and collars **15** and **16**. The lower end of each sleeve is threaded to receive another tubular section, with collar **15** having a lower or long string of conduit **23** threaded therein and collar **16** having a small stub-end **24** threaded therein. The tubular pieces threaded into the collars **15** and **16** serve to hold shear rings **18** clamped in abutment with valve sleeves **17**. A small, shearable, outwardly extending peripheral lip **18*a*** on the shear rings is held between a lower edge of the valve collars **15** and **16** and the upper end of tubular sections **23** and **24**.

Mandrel **12** has one or more ports **25** through the wall thereof, and mandrel **11** has one or more ports **26** through the wall.

A primary piston body **27** is located slidably and relatively snugly about primary mandrel **11** and secondary mandrel **12** and covers ports **26**. Mandrel **11** has an annular piston shoulder **28** extending outward into an inner enlarged annular chamber area **29** in body **27**. Shoulder area **28** has an O-ring seal groove **30** with a seal **31** therein; a shear groove **32** and locking groove **33** below the seal groove **30**.

An annular pressure responsive area **34** is located at the upper end of chamber **29** in body **27** and another annular pressure responsive area **35** is formed on shoulder **28** of mandrel **11**.

Body **27** has inner annular seal grooves **36** and **37** which contain circular seals **38** and **39** arranged to provide fluidic sealing between mandrel **11** and sleeve **27**. Body **27** also has one or more large flow ports **40** passing through a lower extended skirt section **41** which skirt contains an enlarged inner bore **42**.

A lower abutment ring **43** is securedly attached to mandrel **11** by means such as threads and abuts the lower end of shoulder **28** of the mandrel.

Secondary mandrel **12** has an upper exterior annular shoulder **44** formed thereon having a groove **45** therein in which is located resilient circular seal **46**. A cylindrical, pressure-responsive closing sleeve **47** slidably encircles mandrel **12** and shoulder **44** in relatively snug fitting relationship. A radially inwardly projecting annular piston shoulder **48** is formed at the lower end of sleeve **47** and together with shoulder **44** forms expansion chamber **49**. Shoulder **48** fits closely to mandrel **12** and contains in an annular groove **50** a resilient sealing ring **51** engaging the mandrel **12** and groove **50**. Chamber **49** is arranged to communicate through the one or more ports **25** to bore **8**.

Mandrel **12** passes in slightly loose-fitting relationship through a cylindrical bore **52** formed in body **27** so that mandrel **12** is loosely encircled by the body. This provides a substantial amount of lateral support against large distortions of mandrel **12** away from mandrel **11** while also allowing the tool to be assembled in a most convenient manner. Limited upward and downward movement of mandrel **12** in body **27** is allowed although restrained past a certain point by the interaction of a two piece hard metal C-ring **53** in an annular external channel **54** formed in mandrel **12**. C-ring **53** at its upper edge abuts an inner shoulder **55** of abutment ring **43** and at its lower edge abuts an assembly sleeve **56** which encircles mandrel **12** and is threadedly engaged in ring **43** into abutment with ring **53**.

The interaction of shoulder **55** and sleeve **56** fixedly secures C-ring **53** to abutment ring **43**. The channel **54** is of sufficient axial length to allow telescopic movement of mandrel **12** in and out of abutment ring **43** to allow assembly of the tool and attachment into the production string. This allows both vertical and rotational movement of the secondary mandrel within the body of an amount sufficient to allow ease in assembling the apparatus.

Mandrels **11** and **12** being secured together by ring **43** are further attached shearably to body **27** to prevent premature operation of the valve assembly such as when going in the hole. This is done by the placement of threaded shear screws **57** in body **27** which project radially inward toward primary mandrel **11** to engage in shear groove **32** in the mandrel. FIG. **3**, which is an end cross-sectional view looking down the central axis of the piston body **27** from line 3–3 in FIG. 2, illustrates more clearly the shear screw assembly in the body **27** and mandrel **11**.

In FIG. **3**, a generally cylindrical shear screw **57** has a large threaded end **57***a*, a narrowed intermediate shear section **57***b*, and a groove engagement button **57***c* adapted to snugly engage in groove **32**. Shear screw **57** has a slot or allen-head socket **57***d* for screwing the threaded section **57***a* into the threaded bore **58** in the body.

Also in FIG. **3** is shown a locking pin assembly **60** in a radial bore **59** in piston body **27**. This assembly utilizes a generally cylindrical locking pin **61** slidably mounted in a relatively snug fit in bore **59** which is directed radially inward at mandrel **11**. An external flange **61***a* at the outer end of pin **61** extends into abutment with an inwardly projecting annular shoulder **59***a* of bore **59** to limit movement of pin **61** inwardly.

A resilient element **62** such as a coil spring, belleville spring, or Z-spring is held in compressive abutment against the outer end of pin **61** by a threaded plug **63** which is threadedly engaged in the threaded section of bore **59**. Spring element **62** serves to keep pin **61** in contact with the mandrel until a recessed area on the mandrel comes under pin **61** such that shoulder **61***a* then abuts bore shoulder **59***a*. Pin **61** is necessarily larger than shear groove **32** to prevent its assuming a locking position in that groove. Locking groove **33** is sufficiently larger than pin **61** to allow it to seat therein and, because of abutment therewith, to lock piston body **27** and mandrel **11** together at the desired time.

In typical operation, the circulating valve assembly as illustrated in FIGS. **2** and **3** is attached to a dual production string below a dual production packer. A permanent packer is set in the borehole between the producing formations. The dual production string is lowered into the borehole until the long string projecting downward from valve assembly **10** is stabbed into the permanent packer. The valve assembly **10** remains closed while going in the borehole.

After the long string is stabbed into the permanent packer and the production string is properly positioned in the well, the valve assembly may be actuated to circulate out the heavy drilling mud in the borehole. Actuation to the open position illustrated in FIGS. **4** and **5** is accomplished by applying sufficient pressure to the primary string **11** to cause shearing of shear screws **57**. Pressure may be applied directly to the primary string if the lower formation is strong enough to withstand the pressure, or a valve element **21** may be dropped or pumped down the primary string to seat in valve seat sleeve **17**. It should be noted that the absolute shear value of shear ring **18** should be substantially higher than the cumulative total shear value of all the shear screws **57** to insue proper operation of the valve assembly.

Upon application of pressure to the primary string, the pressure acts through ports **26** and chamber **29**, against pressure responsive faces **34** and **35** thereby applying an upward force to piston sleeve **27** with respect to the mandrels. This force shears screws **57** thereby moving the piston sleeve **27** upward until ports **40** clear seal **31** and communicate with ports **26** thereby communicating the primary string inner bore with that portion of the well annulus between the permanent packer and the surface.

At this time, displacement fluid can be pumped down the conduit strings to displace the heavy fluids out into the annulus and up to the surface, or they may be reversed out by pumping displacement fluids down the annulus and up the conduit strings. The secondary string is circulated through the open bore from the bottom which is open at this time. The circulating configuration of the apparatus is illustrated in FIGS. **4** and **5**.

When circulating is finished the valve can be closed by a second application of hydraulic pressure down the secondary string. A ball valve **21** is first dropped or pumped down the secondary string to seat in sleeve **17**. Application of pressure in the secondary string acts through ports **25** against shoulders **44** and **48** thereby driving the closing sleeve **47** downward thereby moving piston sleeve **27** back downward to cover ports **26** by straddling the ports with seals **38** and **39**.

When the downward movement of sleeves **47** and **27** has continued long enough to align locking pins **61** with locking groove **33**, the pins are urged inward into the groove thereby locking the valve in a permanently closed orientation. AT this time, if desirable, both strings may be pressurized sufficiently to shear the rings **18** and open the bore passages through the conduits by pumping ball and seat valves **17** and **21** down and out of the conduit.

Thus the advantages of this invention are clear; it allows the use of a circulating valve without having to manipulate the tubing to open and close the valve. This also allows the circulation of completion fluids without having to remove tubing seals from the permanent packer. These advantages save rig-time and reduce hazards and equipment damage while displacing fluids. This apparatus also allows pressure testing of the permanent packer before displacing and allows displacing of the long string without unsetting the permanent packer. Opening and closing of the circulating valve can be accomplished independently of the operation of the dual production packer and no wireline tools are needed in the operation.

Although a specific preferred embodiment of the present invention has been described in the detailed description above, the description is not intended to limit the invention to the particular forms or embodiments disclosed herein, since they are to be recognized as illustrative rather than restrictive and it will be obvious to those skilled in the art that the invention is not so limited. For example, whereas O-ring seals and shear rings are described in the apparatus it is obvious that other seal means and different shear means could be utilized. Furthermore, other types of pump down valves could be used in place of the ball and seat valves depicted. For instance, wireline retrievable plugs could be used in place of the ball valves. Furthermore, the dual string circulating valve disclosed herein is extremely advantageous for use between two dual packers in a "stacked" dual installation where the upper packer is a primary-set dual packer. Since the circulating valve is normally opened by pressurizing the primary string, after this string is opened for circulating, the packer cannot be set.

By utilizing this apparatus between the two dual packers in the stacked installation and rotating the circulating tool 180°, it can be converted to a secondary string actuated circulating assembly, thereby allowing later setting of the primary set packer after circulating between the dual packers.

Also, it is clear that while the ball and seat valves are illustrated and described as being located directly below the mandrels **11** and **12**, it would be possible to utilize these mechanisms at any location in the tubing strings below the mandrels without greatly reducing the efficiency of the invention.

The invention is declared to cover all changes and modifications of the specific example of the invention herein disclosed for purposes of illustration, which do not constitute departures from the spirit and scope of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A well valve assembly for use in dual production strings, said assembly comprising:

a tubular elongated primary mandrel having connection means at each end thereof for interconnection with other tubular sections;

a tubular elongated secondary mandrel in generally parallel orientation with said primary mandrel; both of said mandrells having port means through the walls thereof;

a body member encircling both said mandrels in relatively snug slidable relationship, said body member having port means through one side thereof;

first pressure responsive means between said primary mandrel and said body member and communicating with said port means in said primary mandrel; said pressure responsive means arranged to move said body member axially on said primary mandrel upon application of fluid pressure through said primary mandrel port means to said first pressure responsive means, whereby said body member ports are placed in communication with said primary mandrel ports; and

second pressure responsive means on said secondary mandrel in communication with said secondary mandrel ports and arranged to move said body member in response to fluid pressure applications to said secondary mandrel, whereby said body member is moved to block fluid communication from said primary mandrel port means to said body member port means.

2. The well valve assembly of claim **1** further comprising shear means between said body member and said primary mandrel, said shear means arranged to frangibly attach said body member to said primary mandrel to temporarily prevent slidable movement therebetween.

3. The well valve assembly of claim **1** further comprising selective locking means between said body member and said primary mandrel and arranged to abut said body member and said primary mandrel and prevent telescopic movement therebetween when said body member achieves a preselected position on said primary mandrel.

4. The well valve assembly of claim **3** wherein said selective locking means further comprises:

locking pin means slidably mounted in said body member;

resilient biasing means abutting said locking pin means and urging said locking pin means towards said primary mandrel;

retaining means in said body member for preventing said locking pin means from moving completely out of said body; and,

abutment channel means formed in said primary mandrel and adapted to fittingly receive said locking pin means.

5. The well valve assembly of claim **1** further comprising rigid attachment means fixedly connected to said primary mandrel and movably connected to said secondary mandrel, said attachment means arranged to allow limited axial movement of said secondary mandrel and unlimited rotational movement of said secondary mandrel.

6. The well valve assembly of claim 5 wherein said attachment means comprises:
an attachment body having two bore passages therethrough containing said primary and secondary mandrels;
the first of said passages having connection means therein;
connection means on said primary mandrel adapted to be secured into said bore passage connection means;
abutment means in the second of said bore passages, said abutment means abutting an inner shoulder formed in said second bore passage and projecting radially inward into said bore passage;
an elongated annular channel formed in said secondary mandrel, adapted to receive said abutment means, and substantially longer than said abutment means; and,
an abutment sleeve inserted concentrically in said second bore passage, fixedly attached therein, and abutting said abutment means in clamping arrangement with said inner shoulder.

7. The well valve assembly of claim 1 wherein said first pressure responsive means further comprises:
an external annular piston shoulder formed on said primary mandrel in close proximity to said primary mandrel port means;
an expansion chamber formed annularly in said body member adjacent said piston shoulder and arranged to receive said piston shoulder therein, said chamber arranged to communicate with said primary mandrel port means in a first position of said body member on said primary mandrel;
opposed pressure areas on said piston shoulder and in said chamber arranged to receive fluid pressure in said chamber and move in opposite directions; and,
seal means between said primary mandrel and said body member above and below said expansion chamber.

8. The well valve assembly of claim 1 wherein said second pressure responsive means comprises:
annular piston shoulder means formed on said secondary mandrel in close proximity to said secondary mandrel port means;
piston sleeve means slidably encircling said shoulder means and having an inwardly projecting annular shoulder slidably contacting said secondary mandrel;
an expansion chamber formed between said piston shoulder means and said inwardly projecting annular shoulder and concentrically between said secondary mandrel and said piston sleeve means, said chamber arranged to be placed in communication with said secondary mandrel port means;
opposed pressure responsive areas on said piston shoulder means and said inwardly projecting annular shoulder in said expansion chamber; and,
seal means between said piston sleeve means and said secondary mandrel above and below said expansion chamber.

9. The well valve assembly of claim 1 further comprising valve seat means frangibly attached to each of said mandrels; each said valve seat means adapted to receive a valve member in sealing relationship therein to close the inner bore of each said mandrel.

10. A dual circulating valve assembly for use in dual conduit production strings, comprising:
a generally circular body member having two aligned cylindrical bore passages extending therethrough;
an elongated tubular primary mandrel extending telescopically through the first of said bore passages;
piston shoulder means on said primary mandrel and port means through the wall of said primary mandrel in close proximity to said shoulder means;
piston chamber means in said first bore passage arranged to receive said shoulder means;
an elongated tubular secondary mandrel extending through the second of said bore passages and slidably and rotatably held therein;
port means through the wall of said secondary mandrel;
seocnd piston means in said valve assembly arranged in conjunction with said secondary mandrel port means to receive fluidic pressure therethrough and further arranged to apply force to said body member; and,
flow passage means from said primary mandrel through said body member, said flow passage means arranged to be opened and closed by axial movement of said body member on said primary mandrel.

11. The circulating valve assembly of claim 10 wherein said primary and secondary mandrels and said body member are all cylindrical in configuration and are arranged so that their longitudinal axes are generally parallel.

12. The circulating valve assembly of claim 10 further comprising preselective resiliently biased locking means in said body member arranged to abut said primary mandrel and lock said mandrel to said body member when said body member is located on said mandrel such as to position said locking means over an abutment channel formed in said primary mandrel; said abutment channel adapted to receive said locking means.

13. The circulating valve of claim 12 further comprising frangible shear means initially securing said body member to said primary mandrel in a position blocking said primary mandrel port means.

14. The circulating valve assembly of claim 13 wherein said second piston means comprises:
an annular piston shoulder formed externally on said secondary mandrel and arranged to communicate with said secondary mandrel port means;
a slidable external piston sleeve mounted slidably on said annular piston shoulder;
an inner annular sleeve shoulder internally formed in said sleeve and slidably contacting said secondary mandrel opposite said secondary port means from said annular piston shoulder;
first seal means between said annular piston shoulder and said piston sleeve; and,
second seal means between said sleeve shoulder and said secondary mandrel.

15. The circulating valve assembly of claim 14 wherein said piston sleeve is abuttingly arranged against said body member.

16. The circulating valve assembly of claim 15 further comprising a valve seat conduit attached to each of said mandrels, with each said conduit containing therein a valve seat sleeve frangibly attached to said conduit, said seat sleeve adapted to receive in sealing

engagement a valve element and arranged to block passage through each said conduit upon seating of a valve element therein.

17. The circulating valve assembly of claim **16** further comprising abutment and assembly means fixedly attached to said primary mandrel and movably secured to said secondary mandrel and arranged to allow unlimited rotational movement and restricted axial movement of said secondary mandrel therein; said attachment and assembly means comprising:

an attachment body encircling both of said mandrels and arranged to limit downward movement of said body member by abutment therewith;

an annular abutment ring located concentrically within said attachment body and abutting an inner annular shoulder in said attachment body; and,

an assembly ring securedly attached to said attachment body and abutting and clamping said abutment ring in said body;

said abutment ring projecting radially inwardly from said attachment body, and said secondary mandrel having an elongated peripheral abutment channel formed thereon substantially larger than said abutment ring and arranged to receive said abutment ring in slidable contact therein.

18. A dual string valve assembly for completion and production of multizone oil wells, said valve assembly comprising:

a generally cylindrical body having two cylindrical bore passages extending axially therethrough;

a primary mandrel slidably mounted in one of said bore passages, said mandrel having an open bore therethrough, primary port means through the wall thereof, and primary piston shoulder means located externally thereon;

a tubular secondary mandrel slidably located in the second of said bore passages and having secondary port means through the wall thereof and secondary piston shoulder means thereon;

a piston chamber formed internally in the wall of said body in said first bore passage and adapted to receive said primary piston shoulder means slidably and sealingly therein, said chamber arranged to be placed in communication with said primary port means;

a secondary piston sleeve slidably mounted on said secondary piston shoulder and said secondary mandrel and having an enlarged inner bore section forming a secondary chamber in communication with said secondary port means;

frangible shear means attaching said body to said primary mandrel; and,

attachment means securedly attached to said primary mandrel in abutting relationship with said body, and movably attached to said secondary mandrel to allow unlimited rotational and restricted axial movement of said secondary mandrel in said attachment means.

19. The valve assembly of claim **18** further comprising:

a plurality of resiliently biased locking members slidably mounted in said body member and urged into abutment with said primary mandrel;

locking abutment channel means on said mandrel adapted to receive said locking members in abutting relationship therewith; and,

valve seating means attached to the lower end of each said mandrel, having a flow passage therethrough, and adapted to receive a valve member in seated relationship therein to block said flow passage.

20. The valve assembly of claim **19** wherein said valve seating means on said mandrels each comprises a tubular conduit containing a valve seating sleeve having a bevelled valve seat circumscribing a flow passage therethrough, each said seating sleeve being frangibly secured to said conduit; and,

said shear means in said body comprising a plurality of shearable screws secured in said body and projecting inwardly into said first bore passage, with said primary mandrel having a shear groove formed peripherally thereon and arranged to receive said shearable screws in abutment therein.

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