US 20030079878A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2003/0079878 A1

Pramann, II et al. (43) Pub. Date: May 1, 2003

(54) COMPLETION SYSTEM, APPARATUS, AND METHOD

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(21) Appl. No.: **10/280,400**

(22) Filed: **Oct. 25, 2002**

Related U.S. Application Data

(60) Provisional application No. 60/339,512, filed on Oct. 26, 2001.

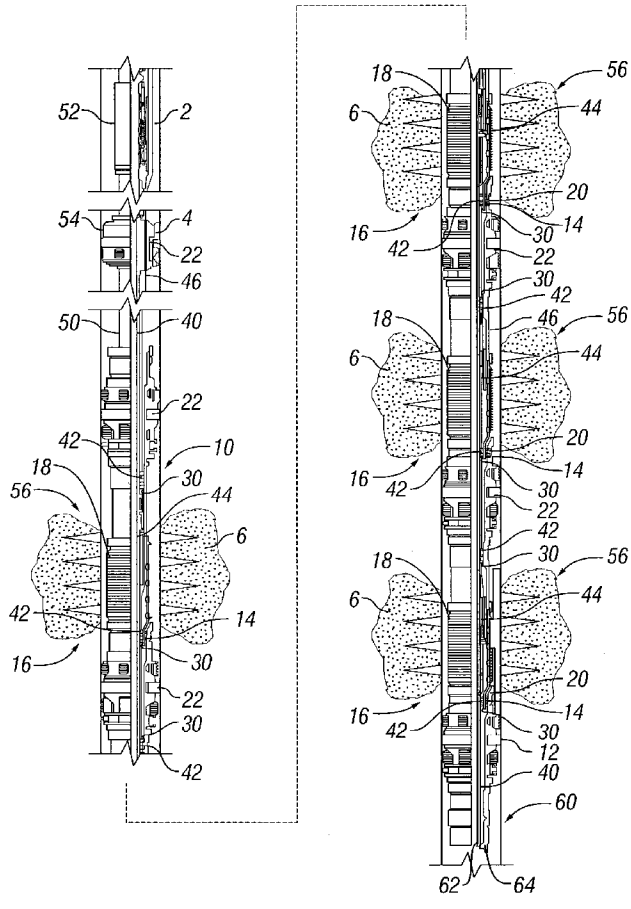
Publication Classification

(51) **Int. Cl.**[7] **E21B 43/04**; E21B 17/00; E21B 23/00

(52) **U.S. Cl.** **166/278**; 166/381; 166/242.3

(57) **ABSTRACT**

A well completion has an inner completion with a control valve surrounded by spaced seals that is positioned in an outer completion, such as a sand control completion. A control line extends from the valve through one of the seals. It is emphasized that this abstract is provided to comply with the rules requiring an abstract which will allow a searcher or other reader to quickly ascertain the subject matter of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. 37 CFR 1.72(b).



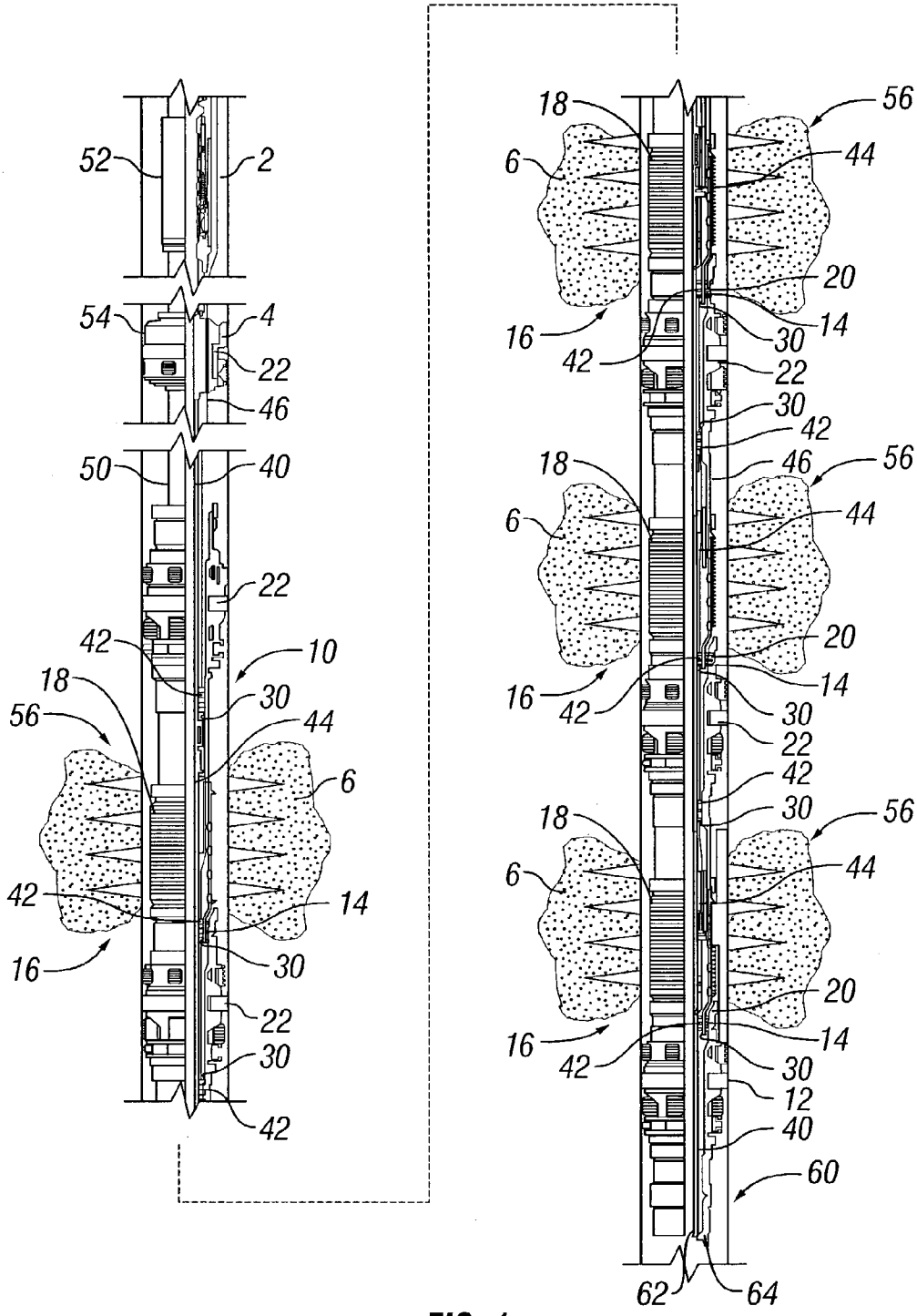

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FIG. 1

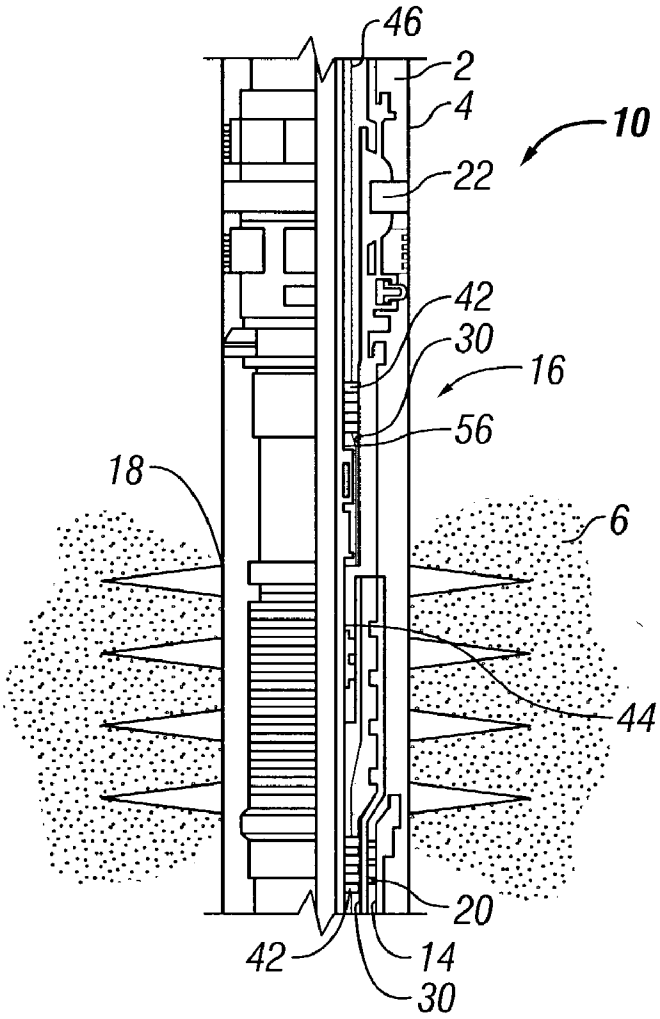

FIG. 2

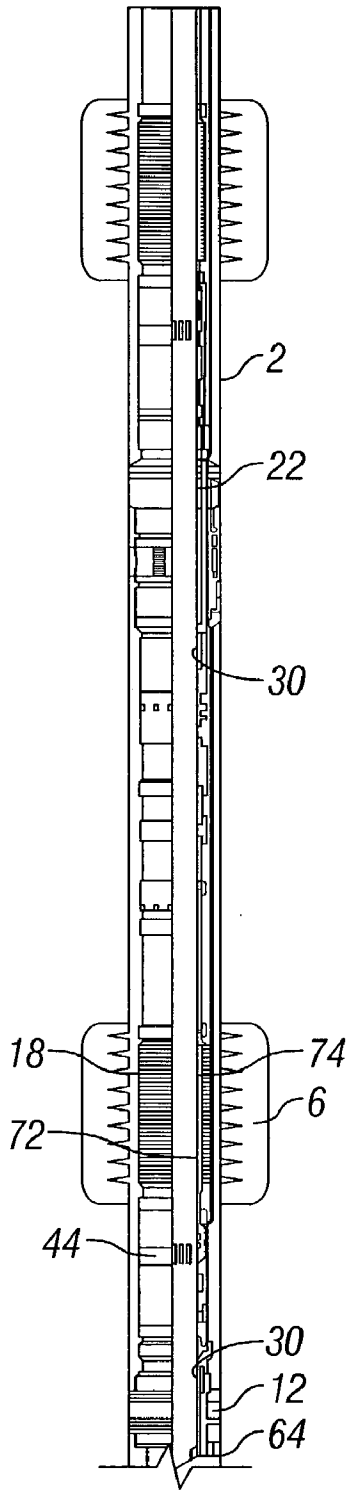

FIG. 3

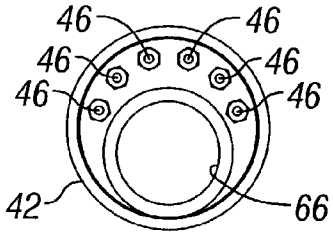

FIG. 4

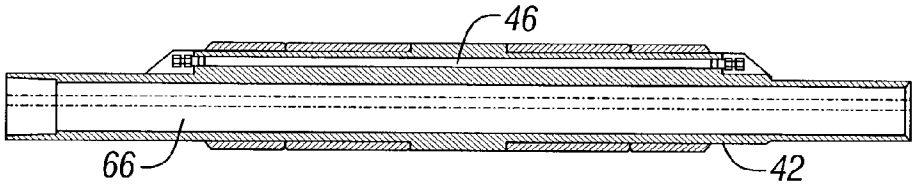

FIG. 5

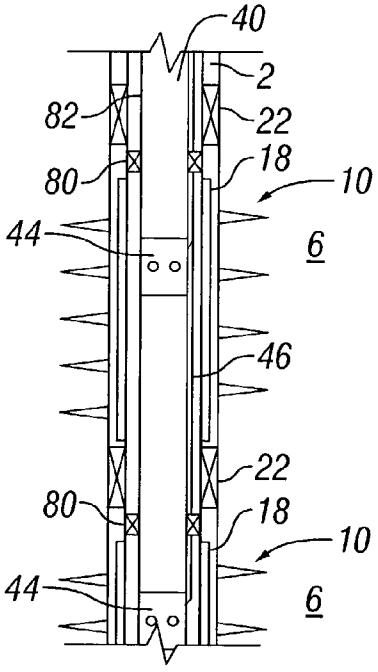

FIG. 6

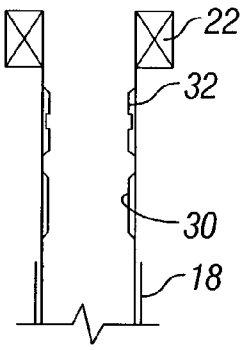

FIG. 7

COMPLETION SYSTEM, APPARATUS, AND METHOD

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The following is also based upon and claims priority to U.S. provisional application serial No. 60/339,512, filed Oct. 26, 2001.

BACKGROUND OF THE INVENTION

[0002] 1. Field of Invention

[0003] The present invention relates to the field of completions. More specifically, the invention relates to a device and method for a completing a well using an inner completion string.

[0004] 2. Related Art

[0005] Oil companies are continually improving their recovery systems to produce oil and gas more efficiently and economically from sources that are continually more difficult to exploit, without significantly increasing the cost to the consumer. One relatively recent development to increase production is the use of intelligent completions. Intelligent completions generally include downhole monitoring devices and control devices that are remotely actuatable from the surface. Intelligent completions as well as other types of completions require the use of control lines (e.g., electrical, fiber optic, and hydraulic lines and combinations thereof) that extend through the well to equipment positioned therein. Routing of the control lines is often an issue in a number of completions. For example, in sand control completions, the control line is typically run with the sand screens that are then gravel packed. When the production string is run and stabbed into the polished bore receptacle (PBR) of the sand screen completion, the control lines installed with the sand control completion must be connected to the surface. This connection is generally made with a wet connect which are generally considered undesirable.

[0006] Additionally, once the sand control completion is gravel packed in the well, it is very difficult or impossible to remove. Accordingly, the equipment installed in the sand control completion generally cannot be replaced easily.

[0007] In sand control completions having multiple zones, it is desirable to separate the production from and injection into the various zones.

[0008] Also, there is a need for remedial completions inside preexisting completions or as a redundant option for new completions.

SUMMARY

[0009] In general, according to one embodiment, the present invention provides a sand control completion in which an inner completion is run into a sand screen. The inner completion comprises the flow control equipment as well as the control line to the surface. In another embodiment, the present invention comprises an isolation seal assembly having a control line passageway therethrough.

[0010] Other features and embodiments will become apparent from the following description, the drawings, and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The manner in which these objectives and other desirable characteristics can be obtained is explained in the following description and attached drawings in which:

[0012] **FIG. 1** illustrates an embodiment of the present invention showing multiple zones.

[0013] **FIG. 2** illustrations a blown-up portion of **FIG. 1** of the present invention.

[0014] **FIG. 3** illustrates an alternative embodiment of the present invention.

[0015] **FIG. 4** is an end view of an embodiment of a seal assembly of the present invention.

[0016] **FIG. 5** is a side, cross sectional view of an embodiment of a seal assembly of the present invention.

[0017] **FIG. 6** illustrates an alternative embodiment of the present invention.

[0018] **FIG. 7** illustrates an alternative embodiment in which a PBR is positioned between a screen and a circulating valve.

[0019] It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

DETAILED DESCRIPTION OF THE INVENTION

[0020] In the following description, numerous details are set forth to provide an understanding of the present invention. However, it will be understood by those skilled in the art that the present invention may be practiced without these details and that numerous variations or modifications from the described embodiments may be possible.

[0021] Although the figures show the invention used in a multi-zone completion, the present invention may be used in a single zone completion. Further, the present invention may be employed in some of the zones (e.g., one of the zones) of a multi-zone completion if desired.

[0022] Referring to **FIG. 1, a** well **2** having a casing **4** therein extends through a plurality of perforated zones **6**. Each zone is completed with a sand screen completion **10**. The sand screen completion **10** may be as shown or use other sand screen completion methodologies and equipment. In the embodiment shown, the sand screen completion **10** comprises a sump packer **12** having a polished bore receptacle (PBR) **14** therein. Note that the PBR **30** may be incorporated into a separate piece of the completion. However, it is generally described herein as attached to or part of the packer for ease of discussion. The sump packer **12** is placed and set in the well below a zone **6**. A sand screen assembly **16**, comprising a sand screen **18** and a seal assembly **20** at its lower end, is attached to the lower end of a packer **22**. The sand screen assembly **16** is positioned in the well with the seal assembly **20** in sealing engagement with the PBR **14** of the sump packer **12**. The packer **22** of the sand screen assembly **16**, which also has a PBR **14** therein, is set, thereby isolating the associated zone **6** between the packers **12**, **22**.

[0023] If desired, a service string (not shown) is run into the well and the zone **6** is gravel packed by any desired method. U.S. Pat. No. 6,220,353, issued Apr. 24, 2001, discusses a gravel packing procedure and associated tools and is hereby incorporated by reference. Other methods of gravel packing the zone **6** are known and may be used with the present invention.

[0024] If the well has multiple zones they may also be completed as described above. For example, the seal assembly **20** of a second sand screen assembly **16** stabs into the PBR **14** of the previously installed sand screen assembly **16**. Once the packer **22** of the second sand screen assembly **16** is set, the packers **22** of the two sand screen assemblies **16** isolate the additional, upper zone. The second zone may then be gravel packed. Additional zones may be completed in like manner.

[0025] In an alternative embodiment, a multizone well sand screen completion **10** may be completed as described in U.S. patent application Ser. No. 09/631,859, filed Aug. 3, 2000 which is hereby incorporated herein by reference. In this embodiment, the gravel pack is accomplished through-tubing so that all of the hardware for the sand screen completion **10** for all zones may be installed before the gravel pack operation is performed. Similarly, a multizone well sand screen completion **10** may be completed as described in U.S. Pat. No. 6,311,772, issued Nov. 6, 2001 which is hereby incorporated herein by reference or may be completed in other known manners.

[0026] Above and below each of the sand screens **18** is an inner PBR **30**. Note that, rather than providing inner PBRs **30** above and below each sand screen **18** in each sand screen assembly **16** of a multi-zone well **2**, each sand screen assembly **16** may have one inner PBR **30** below the sand screen **18**. However, the overall completion has at least one PBR **30** between the zones of the well. The inner PBR **30** of the two sand screen assemblies **16** providing isolation of the lowermost of the two sand screen assemblies **16**. The uppermost sand screen assembly **16** of the sand control completion **10** would then have an inner PBR **30** above its sand screen **18** to provide for isolation of that uppermost zone. However, the use of an upper and lower inner PBR **30** in each sand screen assembly **16** provides a redundant seal and a more reliable system. Generally, the sand screen assemblies **16** have a circulating valve **32** (**FIG. 7**) above the sand screen **18** that is used during gravel packing. The upper inner PBR **30** provides additional reliability in the case of a leak in the circulating valve. If a PBR **30** is placed between the circulating valve and the sand screen **18**, the circulating valve is isolated from the production by the PBR **30** once a completion **40** (discussed below) is put into place.

[0027] A completion **40** run into the well **2** is inserted into the sand screen completion **10**. Seal assemblies **42** of the completion **40** mate with the inner PBRs **30** to isolate the associated zone(s). Flow entering the annulus formed between the sand screen **18** and the completion **40** is controlled with valves **44** in the completion **40**. The seal assemblies **42** and inner PBRs **30** provide for the control of flow through the valves **44**. Control lines **46** extend along the completion **40** through the seal assemblies **42** to provide power and telemetry to the valves **44** or other equipment in the well **2**.

[0028] In the embodiment shown, the completion **40** comprises a production tubing **50** (or conduit) extending to the surface of the well **2**. A safety valve **52** and a packer **54** are positioned in the well **2** about the production tubing **50** above the sand control completion **10**. A seal assembly **42** attached to the production tubing **50** mates with the uppermost inner PBR **30**. Below the seal assembly **42**, is a control valve **44**. A seal assembly **42** below the control valve **44** mates with the inner PBR **30** below the sand screen **18** of the associated zone **6** to isolate the zone. Together, the seal assemblies **42** above and below a control valve **44** and the equipment therebetween are referred to collectively as an isolation assembly **56**. **FIG. 2** illustrates one isolation assembly **56**. Although primarily described herein as isolating a single zone **6**, an isolation assembly **56** may bridge more than one zone **6** if desired.

[0029] A control line **46** extends from the valve **44** and through the seal assembly **42** to a position above the sand control completion **10**. Generally, the control line **46** extends to the surface, but may extend to a downhole controller, power supply, or telemetry equipment, such as an inductive coupler or acoustic transmitter. Examples of control lines **46** are electrical, hydraulic, fiber optic and combinations of thereof. Other equipment may also be provided in the isolation assembly **56** or isolated portion that requires a control line **46** connected thereto. For example, the completion **40** may have intelligent completions devices such as gauges, sensors, valves, sampling devices, temperature sensors, pressure sensors, flow rate measurement devices, oil/water/gas ratio measurement devices, scale detectors, actuators, locks, release mechanisms, equipment sensors (e.g., vibration sensors), sand detection sensors, water detection sensors, data recorders, viscosity sensors, density sensors, bubble point sensors, composition sensors, resistivity array devices and sensors, acoustic devices and sensors, other telemetry devices, near infrared sensors, gamma ray detectors, H_2S detectors, CO_2 detectors, downhole memory units, downhole controllers, locators, and other downhole devices therein. In addition, the control line **46** itself may comprise an intelligent completions device as in the example of a fiber optic line that provides functionality, such as temperature measurement, pressure measurement, and the like. In one example, the fiber optic line provides a distributed temperature functionality so that the temperature along the length of the fiber optic line may be determined. The control line **46** for such equipment would also extend through the seal assembly **42**.

[0030] In a multi-zone well, such as that shown in **FIG. 1**, the completion **40** has additional isolation assemblies **56** corresponding to associated zones **6** as desired.

[0031] In one embodiment, a locator device **60** ensures the proper alignment between the completion **40** and the sand control completion **10**. An example of a locator device is shown in **FIG. 1**. In that example, the bottom **62** of completion **40** lands on a shoulder **64** connected to a lower end of the sand control completion **10**. In that example, the shoulder **64** is positioned below the sump packer **12**. Numerous other types of locators may be used.

[0032] **FIGS. 4 and 5** provide a more detailed illustration of the seal assembly **42**. In many cases, the radial limitations of placing a completion **40** within the sand control completion **10** are stringent. To facilitate placement of the control lines **46** in the radially restricted space, the seal assembly **42** may be eccentric with the primary production passageway

66 offset from the centerline of the seal assembly 42. An eccentric arrangement provides a relatively thicker side through which control line(s) 46 may extend. The control lines 46 extend through control line passageways provided in the body of the seal assembly 42.

[0033] In another embodiment, shown in FIG. 3, the completion 40 is used in conjunction with a preexisting completion 70 to provide a remedial system. As an example, a completion 70, as described in U.S. patent application Ser. No. 09/732,134, filed Dec. 7, 2000 which is hereby incorporated by reference herein, is provided in a well 2. In one embodiment, the completion 70 has a sand screen 18 with a gravel pack. A base pipe 72 of the sand screen 18 is unperforated and defines a flow annulus 74 between the sand screen 18 and the base pipe 72. The annulus communicates with a flow control valve 44 that controls the flow from the annulus 74 into the production string 50.

[0034] In the present embodiment, the completion 70 further includes a pair of inner PBRs 30 isolating the inlet to the production tubing (i.e., the valve 44 port). For example, an inner PBR 30 may be placed below the valve 44 and above the sand screen 18. In this way, if the valve 44 fails, it can be locked open and an inner completion 40 may be run inside completion 70. As in the previously described embodiment, the seal assemblies 42 of the completion 40 may mate with the inner PBRs to isolate the incoming flow which may then be controlled by the valve 44 in the inner completion 40. This system will work in other situations wherein there is a specific area of ingress into the production tubing and an interior completion 40 is desired to control the flow therethrough, such as in cases of remediation.

[0035] Although the isolation is described herein as using PBRs and seal assemblies, other types of isolation devices, such as packers and cup packers, may be used. In one embodiment an inner completion 40 of the present invention may be used in a pre-existing completion that does not have a PBR. In this embodiment, the inner completion uses inner packers 80 to isolate between the various zones. In this way, an intelligent completion may be provided in an existing well. Referring to FIG. 6, one example of this embodiment is shown. In FIG. 6, the pre-existing completion comprises an upper packer 22, a sand screen 18 in each of the zones, and a packer 22 isolating the two zones. The inner completion 40 comprises a valve 44 for each of the zones and inner packers 80 on isolating the valves 44 from one another. The inner packers 22 seal between the inner string 82 and the pre-existing completion. The inner packers 22 and valves 44 are positioned in the well so that flow of each of the screens or zones is isolated from the flow of other screens or zones (although one valve could be used for multiple zones if desired). A control line 46 may run from the surface or from a downhole controller to each of the valves 44 so that the position of the valve may be controlled. Other intelligent completions devices may be placed in the inner completion 40 as well. The control line 46 may extend through bypass lines in the inner packers 80 which may be eccentric to provide additional area for running of the control lines 46 therethrough.

[0036] When a device is described herein as providing a seal, some leakage through the seal may occur. Thus, a seal includes an arrangement that substantially restricts the flow. The term "seal" as used herein refers generically to seal assemblies, packers, cup packers, and other isolation devices.

[0037] Also note that in each of the above-described embodiments, the sand screen 18 may be replaced with a slotted liner as an alternative form of sand control. The term "sand control device" is used to generally describe sand screens, liners, and other types of conduits used to prevent migration of sand into the production.

[0038] Although only a few exemplary embodiments of this invention have been described in detail above, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention as defined in the following claims. In the claims, means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents, but also equivalent structures. Thus, although a nail and a screw may not be structural equivalents in that a nail employs a cylindrical surface to secure wooden parts together, whereas a screw employs a helical surface, in the environment of fastening wooden parts, a nail and a screw may be equivalent structures. It is the express intention of the applicant not to invoke 35 U.S.C. §112, paragraph 6 for any limitations of any of the claims herein, except for those in which the claim expressly uses the words 'means for' together with an associated function.

We claim:

1. A system for completing a well, comprising:

a sand control device;

a first inner polished bore receptacle above the sand control device;

a second inner polished bore receptacle below the sand control device;

a completion positioned inside the sand control device having a first seal assembly sealingly mating with the first inner polished bore receptacle and having a second seal assembly sealingly mating with the second inner polished bore receptacle;

a valve of the completion positioned between the first and second seal assemblies; and

a control line extending from the valve and through the first seal assembly.

2. The system of claim 1, wherein the sand control device is a sand screen.

3. The system of claim 1, wherein the sand control device is a slotted liner.

4. The system of claim 1, further comprising an intelligent completions device in the completion.

5. The system of claim 1, wherein the control line is a fiber optic line and the fiber optic line that provides functionality.

6. The system of claim 1, wherein:

the first polished bore receptacle has a control line passageway therethrough; and

the control line extends through the control line passageway.

7. The system of claim 1, further comprising:

the first polished bore receptacle has a primary production passageway that is eccentric with respect to a centerline of the first polished bore receptacle.

8. The system of claim 1, further comprising a locator device.

9. The system of claim 1, further comprising:

a second sand control device;

the second first polished bore receptacle is positioned between the sand control device and the second control device.

10. The system of claim 9, further comprising:

a third polished bore receptacle positioned below the second sand control device;

the completion having a third seal assembly sealingly mating with the third inner polished bore receptacle.

11. The system of claim 9, further comprising:

a fourth polished bore receptacle positioned between the sand control device and the second sand control device; and

the completion having a fourth seal assembly sealingly mating with the fourth inner polished bore receptacle.

12. The system of claim 9, further comprising:

a second valve of the completion positioned below the second seal assembly; and

a control line extending from the valve and through the first seal assembly and the second seal assembly.

13. The system of claim 9, wherein the second sand control device is a sand screen.

14. The system of claim 9, wherein the second sand control device is a slotted liner.

15. The system of claim 1, further comprising:

a circulating valve;

one of the first polished bore receptacle and the second polished bore receptacle is positioned between the circulating valve and the sand control device.

16. The system of claim 1, further comprising a gravel pack.

17. A method for completing a well, comprising:

completing a well so as to define an area of fluid ingress into a completion;

positioning a conduit within the completion;

sealing between the conduit and the completion above and below the area of fluid ingress with spaced seals;

controlling the flow into the conduit with a valve; and

routing a control line from the valve through one of the seals.

18. The method of claim 17, further comprising providing a screen at the area of fluid ingress.

19. The method of claim 17, further comprising gravel packing the well.

20. The method of claim 17, further comprising:

completing the well to define a plurality of areas of fluid ingress;

isolating the areas of fluid ingress from one another by sealing between the conduit and the completion above and below the areas of fluid ingress with spaced seals;

independently controlling the flow into the conduit from each of the areas of fluid ingress.

21. The method of claim 17, wherein the sealing comprises inserting a seal assembly attached to the conduit into a mating polished bore receptacle of the completion.

22. The method of claim 17, further comprising measuring a parameter between the spaced seals.

23. The method of claim 17, further comprising engaging a locator device and ensuring proper alignment between the completion and the conduit.

24. The method of claim 17, further comprising isolating a circulating valve of the completion with one of the spaced seals.

25. A system for controlling flow in a well having a sand control completion therein, comprising:

an inner completion comprising a tubing, a first seal, a second seal, and a valve between the first seal and the second seal;

the first seal positioned and adapted to seal above a sand screen of the sand control completion;

the second seal positioned and adapted to seal below the sand screen;

a control line extending from the valve and through the first seal.

26. The system of claim 25, further comprising an intelligent completions device of the inner completion.

27. The system of claim 25, wherein:

the first seal has a control line passageway therethrough; and

the control line extends through the control line passageway.

28. The system of claim 25, further comprising:

the second seal is positioned to seal between two sand screens of the sand control completion.

29. The system of claim 28, further comprising:

a third seal of the inner completion is positioned and adapted to seal below a second sand screen of the sand control completion.

30. The system of claim 28, further comprising a fourth seal of the inner completion positioned and adapted to seal between the two sand screens.

31. The system of claim 28, further comprising a second valve of the inner completion positioned below the second seal.

32. The system of claim 25, further comprising:

one of the first seal and the second seal is positioned to seal between a circulating valve of the sand control completion and the screen.

33. A method of controlling flow in a well having a sand control completion therein, comprising:

running an inner completion into the sand control completion;

sealing between the inner completion and the sand control completion above a sand screen of the sand control completion to create an isolation zone;

controlling a valve of the inner completion to selectively control the flow into the inner completion, the valve positioned in the isolation zone.

34. The method of claim 33, further comprising running a control line from the valve through a seal used to seal between the inner completion and the sand control completion.

35. The method of claim 33, further comprising

isolating multiple zones of the sand control completion with the inner completion;

controlling the flow from each of the zones into the inner completion using valves controlled from the surface.

36. The method of claim 33, further comprising measuring a parameter of the isolated zone using an intelligent completions device of the inner completion.

37. The method of claim 33, further comprising isolating a circulating valve of the sand control completion with the sealing between the inner completion and the sand control completion.

38. The method of claim 33, further comprising sealing between the inner completion and the sand control completion below the sand screen of the sand control completion.

39. A seal assembly, comprising:

a body;

an eccentric passageway through the body defining a relatively thick portion of the wall;

a control line passageway in the thick portion.

40. A system for controlling flow in a well having a sand control completion therein, comprising:

an inner completion positioned in the sand control completion;

means for sealing between the inner completion and the sand control completion above a sand screen of the sand control completion to create an isolation zone;

means for selectively controlling a flow into the inner completion in the isolation zone.

* * * * *