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METHODS AND APPARATUS FOR COMPLETING OIL AND GAS WELLS

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Fig. 1

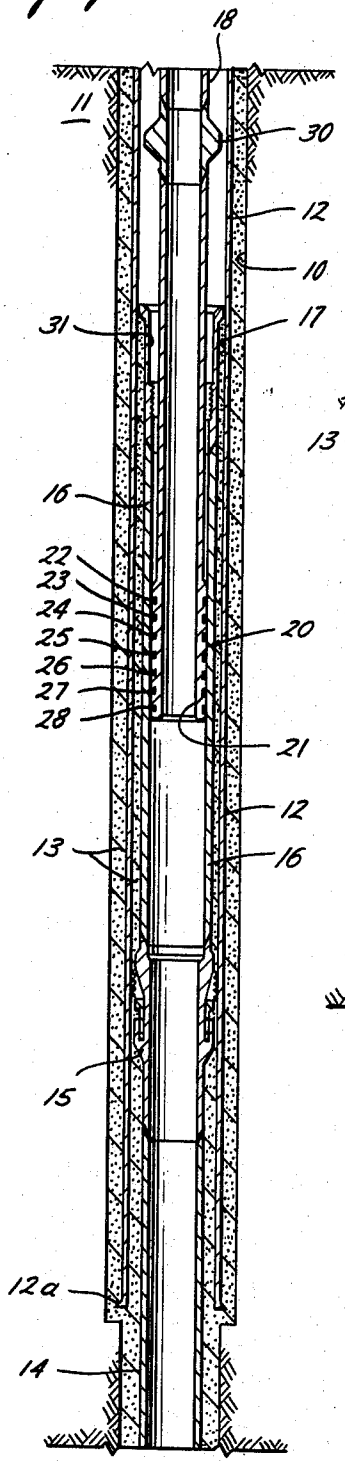


Fig. 2

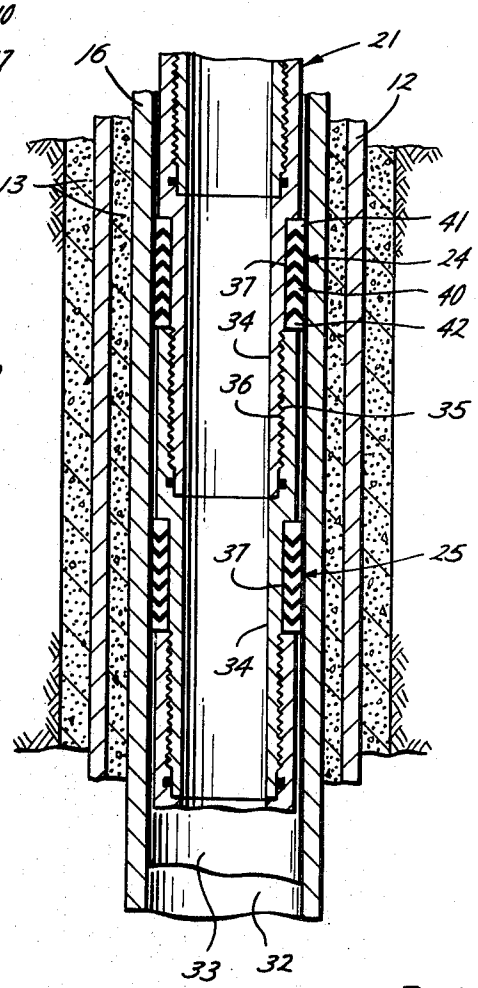
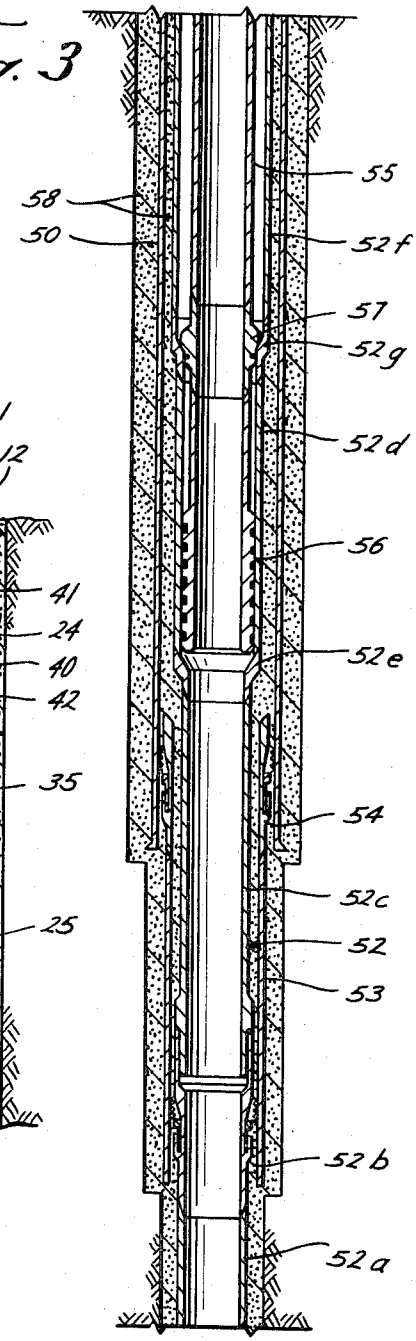


Fig. 3



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METHODS AND APPARATUS FOR COMPLETING OIL AND GAS WELLS

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ABSTRACT OF THE DISCLOSURE

A fluid seal is provided between a permanent production liner string and a removable production tubing string by connecting an elongated tubular receptacle into the liner string at the point at which the seal is desired. The interior of the receptacle is coated with Teflon and the receptacle is permanently cemented into place in the oil or gas well borehole along with the liner string. A tubular sealing assembly is connected to the lower end of the production tubing string. Such sealing assembly includes a series of exteriorly located annular packing seal units and is run into the Teflon coated liner string receptacle to provide the desired fluid seal. A sealing unit may consist of a stack of chevron shaped sealing rings composed of a mixture of fluoroelastomer and asbestos, with fluorocarbon plastic adapter rings at each end of the stack.

BACKGROUND OF THE INVENTION

This invention relates to methods and apparatus for completing oil and gas wells. While not limited thereto, the present invention is particularly useful in the completion of deep wells drilled 20,000 feet or more into the earth and in the completion of high pressure gas wells at these or lesser depths.

As is known, the completion of oil and gas wells which extend to depths of 20,000 feet and more is not an easy task. The extreme depth, high pressure, high temperature, large production rates and high stimulation treatments which are frequently required present numerous problems.

In a typical deep well completion, casing is run to a depth of about 15,000 feet and cemented into place in the borehole. A string of production liner is run into the remaining 5,000 feet or more constituing the lower part of the hole. The upper end of the liner string is secured within the lower joint of the casing by a suitable liner hanger device and the liner string is cemented into place. A permanent production packer is then set in the liner string near the top thereof. The lower end of a production tubing string running from the surface of the earth is set into the production packer and latched therein. In order to accommodate the some twenty feet or more of expansion and contraction changes of the tubing string length which can occur during the different formation treatment and production operations, an expansion joint is usually provided in the tubing string a short distance above the production packer.

A major problem with completion setups of this type, particularly in the case of high pressure gas wells, is the problem of leaks from the tubing string into the surrounding casing string. These leaks have been found to occur in the tubing connections, the production packer, the expansion joints, and so forth. It would be desirable, therefore, to provide an improved and simplified form of completion apparatus which largely eliminates these leaks.

Another problem occurs in the event that a workover operation must be performed which requires re-entry into the production liner string. In this event, after the tubing

string is removed, the production packer must be drilled out and either retrieved or pushed to the bottom of the hole. This procedure gives rise to the definite possibility of fluid and debris contamination of the producing zone.

SUMMARY OF THE INVENTION

It is an object of the invention, therefore, to provide new and improved methods of completing deep oil and gas wells.

It is another object of the invention to provide new and improved apparatus for simplifying the production equipment needed in a deep well completion.

It is a further object of the invention to provide new and improved well completion apparatus which eliminates the need for setting production packers.

It is an additional object of the invention to provide a new and improved method for providing a fluid seal between a production liner string and a production tubing string which simplifies later re-entry into the production liner string for performing workover operations therein.

It is another object of the invention to provide new and improved apparatus for providing a fluid seal between a production liner string and a production tubing string which minimizes the likelihood of future difficulty in removing the tubing string from the well.

It is a further object of the invention to provide new and improved well completion apparatus which provides in a single unit the functions heretofore provided by separate production packer apparatus and expansion joint apparatus.

In accordance with one feature of the invention, apparatus for use in completing oil and gas wells comprises an elongated tubular receptacle member adapted to be permanently connected into a string of permanent production liner and having its interior wall surface coated with a layer of insulation material. The apparatus also includes a tubular support member adapted to be connected to the lower portion of a string of removable production tubing and having an outside diameter which is less than the inside diameter of the receptable member. The apparatus further includes a series of annular packing seal units exteriorly mounted on the support member and having a maximum uncompressed outside diameter which is greater than the inside diameter of the receptacle member. The portion of the support member on which the packing seal units are mounted is adapted to be positioned within the receptacle member for cooperating with same for providing a fluid seal between the production liner and the production tubing and for enabling a substantial longitudinal expansion and contraction of the production tubing without breaking this fluid seal.

In accordance with another feature of the invention, a method of completing oil and gas well boreholes drilled into the earth comprises lowering casing into the upper part of the borehole. The method also comprises connecting the elongated tubular receptacle member into a string of production liner. The method further comprises lowering the production liner and receptacle member into the borehole through the casing until a substantial portion of the production liner extends into the lower part of the borehole below the lower end of the casing. The method also includes cementing the casing, production liner and receptacle member in place in the borehole. The method further comprises connecting a sealing assembly including the annular packing seal units to the lower portion of a string of removable production tubing. The method also comprises lowering the production tubing into the casing and placing the packing seal units inside of the liner string receptacle member. The method additionally includes securing the production tubing to the wellhead equipment.

For a better understanding of the present invention, together with other and further objects and features thereof, reference is had to the following description taken in connection with the accompanying drawing, the scope of the invention being pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWING

Referring to the drawing:

FIG. 1 is a cross-sectional view of a portion of an earth borehole showing in place therein a cross-sectional view of well completion apparatus constructed in accordance with one embodiment of the invention;

FIG. 2 is an enlarged cross-sectional view of a portion of the FIG. 1 apparatus; and

FIG. 3 is a cross-sectional view of an earth borehole and well completion apparatus in accordance with another embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, there is shown a section of a borehole **10** drilled through subsurface earth formations **11**. The section shown in FIG. 1 represents an approximately one hundred foot length of the borehole located at a subsurface depth of, for example, about 15,000 feet. Cemented into place in the borehole **10** is a string of casing **12** which runs from the surface of the earth to a depth of, for example, 15,000 feet. The lower end of the casing string **12** is indicated at **12***a*. The cement is indicated at **13**. Extending from the lower end of the casing **12** is a string of permanent production liner **14** which extends to the lowermost hydrocarbon producing zone near the bottom of the borehole **10**. The borehole **10** may have an overall length of, for example, 20,000 feet or more, in which case the production liner string **14** may extend some 5,000 feet or more below the lower end of the casing string **12**.

Connected to the top of the production liner string **14** is a liner hanger **15** for clamping the liner string to the interior wall of the lower joint of the casing string **12**. Liner hanger **15** may be of a known cone and slip type construction and may be of either the mechanically or hydraulically operated type. Connected to the upper end of the liner hanger **15** is an elongated tubular receptacle member **16** which constitutes one of the novel features of the present invention. This receptacle member **16** has a length in the range of from twenty to forty feet. In particular, a length of thirty feet has been found to be highly satisfactory for use in wells extending to depths of 20,000 to 25,000 feet. Connected to the upper end of the tubular receptacle member **16** is a tie-back receptacle **17**. As is indicated by the extension of the cement **13** up the annulus between the casing **12** and the receptacle member **16**, the receptacle member **16**, as well as the tie-back receptacle **17** and the liner hanger **15** are cemented into place to form a permanent part of the completed well. The lower part of the production tubing string **14** is, of course, also cemented into place.

In order to carry the subsurface hydrocarbons to the surface, a string of removable production tubing **18** is run into the casing string **12** and coupled to the upper end of the liner string **14**. The tubing string **18** extends to the surface of the earth and is secured to the well head equipment located thereat. In accordance with a novel feature of the present invention, this coupling is provided by a sealing assembly **20** which is connected to the lower end of the tubing string **18** and which cooperates with the tubular receptacle member **16** to provide a highly fluid-tight fluid seal between the production liner string **14** and the production tubing string **18**. This sealing assembly **20** includes a tubular support member **21** having a series of annular packing seal units **22–28** exteriorly mounted thereon. The tubular support member **21** is connected to the lower end of the tubing string **18** by means of a locator sub **30**. The enlarged portion of the locator sub **30** is adapted to cooperate with the enlarged inside diameter of an upper receptacle portion **31** of the tie-back receptacle **17** for purposes of determining the location of the sealing assembly **20** in the receptacle member **16**. In other words, when the locator sub **30** is run into the tie-back receptacle portion **31** and seated at the bottom thereof, then the lower end of the sealing assembly **20** is adjacent the lower end of the receptacle member **16**.

Referring to FIG. 2, there is shown an enlarged view of the FIG. 1 apparatus in the immediate vicinity of the annular packing seal units **24** and **25**. As indicated in FIG. 2, the interior wall surface **32** of the tubular receptacle member **16** is coated with a thin layer of insulation material **33**. The interior wall surface **32** is machined and polished to a relatively smooth finish before the layer of insulation material **33** is coated thereon. Insulation material **33** is a plastic material whose exposed surface has good anti-sticking properties. Fluorocarbon plastic materials and, in particular, polytetrafluoroethylene and fluorinated ethylene-propylene have been found to be particularly suitable for this purpose. Both of these materials are sold under the Du Pont trademark of "Teflon," the former being identified as type TFE "Teflon" and the latter as type FEP "Teflon." The type TFE "Teflon" has a somewhat higher temperature rating and should be used where higher operating temperatures are to be encountered. The thickness of the "Teflon" coating **33** is on the order of 0.002 inch.

As further indicated in FIG. 2, the annular packing seal units, as represented by units **24** and **25**, are mounted in spaced apart recesses formed in the outer portion of the tubular support member **21**. To accomplish this purpose, the support member **21** is made up of a series of annular fittings **34** which are adapted to be connected together to form the lower portion of the support number **21**. In particular, internal threads **35** on the upper portion of one fitting **34** cooperate with external threads **36** on the lower portion of the next fitting **34** for purposes of threading the two fittings together. Each of the annular fittings **34** is provided with a recessed shoulder **37** extending over the mid-portion thereof and running circumferentially around the body of the fitting. When the fittings **34** are threaded together, these shoulders **37** provide the annular recesses in which are mounted the packing seal units, as represented by units **24** and **25**.

Considering in detail the case of the packing seal unit **24**, this unit comprises a plurality of annular sealing rings **40** which are stacked against one another with the stack extending in the longitudinal direction along the support member **21**. Each of these sealing rings **40** is constructed to have an approximately chevron shaped cross-section. Annular adapter rings **41** and **42** are located at the two ends of the sealing ring stack for maintaining the sealing rings **40** in their optimum operating orientation. The sealing rings **40** are formed of a composition material composed of a mixture of fluoroelastomer material and asbestos. A fluoroelastomer material that has been found suitable for this purpose is sold under the Du Pont trademark of "Viton." The adapter rings **41** and **42**, on the other hand, are formed of a fluorocarbon plastic material such as either polytetrafluoroethylene or fluorinated ethylene-propylene.

The sealing rings **40** are constructed so that their maximum uncompressed outside diameter is somewhat greater than the inside diameter of the tubular receptacle member **16**. These sealing rings **40** are, however, sufficiently resilient to enable sufficient compression thereof to allow passage of the sealing assembly **20** into the tubular receptacle member **16**. At the same time, the resilient forces produced by this compression provide an extremely tight fluid seal with the interior wall of the tubular receptacle member **16**. The number of sealing rings **40** in the packing seal unit **24** may vary somewhat to meet the particular application at hand. For deep wells or high

pressure gas wells, there should be at least six of these sealings rings **40** and in some cases as many as ten or more such sealing rings may be provided.

Each of the other annular packing seal units **22, 23,** and **25–28** are constructed in the same manner as that just described for the packing seal unit **24.** The number of packing seal units which are used on any given sealing assembly will depend on the particular conditions in the well in which it is to be used. For deep wells and high pressure gas wells, at least six packing seal units should be provided and, in some cases, as many as ten units may be used. As indicated in FIG. 2, the chevron shaped sealing rings in some of the seal units may point in an upwardly direction, while those in other of the seal units may point in a downwardly direction. On the other hand, all may be arranged to point in the same direction.

The various sealing and adapter rings making up the packing seal units are mounted on the annular fittings **34** before the fittings **34** are threaded together. The subsequent threading together of the fittings **34** serves to lock the sealing and adapter rings in place. The number of packing seal units which can be mounted on the sealing assembly may be increased or decreased by using a greater or lesser number of the fittings **34.**

As further indicated in FIG. 2, the maximum outside diameter of the tubular support number **21** is less than the inside diameter of the tubular receptacle member **16** including the layer of insulation **33** coated thereon. In particular, the maximum outside diameter of the tubular member **21** should be at least 0.04 inch less than the inside diameter of the layer **33.** This provides a clearance of at least 0.02 inch between the tubular member **21** and the inner surface of the layer **33.** This clearance is provided to avoid the possibility of a metal to metal contact between the tubular member **21** and the receptacle member **16.** This, together with the presence of the layer of insulation material **33,** substantially eliminates the occurrence of electrolysis effects. This avoids the corrosive like action of such electrolysis effects and, hence, considerably minimizes the likelihood of future difficulty in removing the tubing string **18** from the well.

As can be seen from FIG. 1, the inside diameter of the tubular receptacle member **16** is at least as large as the minimum inside diameter of the production liner string **14,** including the liner hanger **15** and the tie-back receptacle **17.** It may, in fact, be slightly larger. As a consequence, the receptacle member **16** in no way restricts the passage through the well of a tool or other device which is otherwise capable of passing through the production liner string **14.** This considerably simplifies later re-entry into the production liner string **14** in the event it should be required to perform workover operations therein.

It should be further noted that the completion apparatus shown in FIG. 1 does not require the setting of a production packer. It also does not require the use of a separate expansion joint for allowing for expansion and contraction of the tubing string **18.** In a manner of speaking, the sealing mechanism provided by the receptacle member **16** and the sealing assembly **20** provides both the packing function and the expansion joint function. This it does in a simplier and more reliable manner than that in which these functions have been heretofore provided.

In the initial setup of the apparatus shown in FIG. 1, when the tubing string **18** is first run into place, it is run to a depth such that the locator sub **30** is seated in the bottom of the tie-back receptacle portion **31.** This places the lower end of the sealing assembly **20** adjacent the lower end of the receptacle member **16.** With the tubing string **18** in this position, the upper end of such tubing string **18** is then secured to the wellhead equipment. During any subsequent acidizing treatment operations or when the well is put into production, the downhole temperatures will decrease. This will cause a contraction of the tubing string **18,** which contraction will cause the sealing assembly **20** to move upwardly within the receptacle member **16.** The length of the receptacle member **16** is sufficient so that the portion of the sealing assembly **20** on which are located the packing seal units **22–28** will not be withdrawn from the receptacle member **16.**

Referring now to FIG. 3, there is shown a somewhat different embodiment of well completion apparatus in accordance with the present invention. The apparatus of FIG. 3 includes a casing string **50** which is run into the hole and cemented into place in the same manner as in FIG. 1. In the FIG. 3 embodiment, however, there is provided a production liner string **52** which extends all the way from the surface of the earth to the bottom of the borehole. The portion of this liner string **52** which is shown in the one-hundred feet or so of borehole illustrated in FIG. 3 includes a lower liner section **52***a* which is hung inside of an intermediate casing **53** by a liner hanger **52***b*. Intermediate casing **53** is hung from the primary casing **50** by a casing hanger **54.** A further section **52***c* of the liner string **52** is latched into the liner hanger **52***b*. Continuing in the upwardly direction, a further liner section **52***d* is connected to the upper end of the section **52***c* by a swage member **52***e*. This liner section **52***d* is a tubular receptacle member of the same construction as the receptacle member **16** of FIG. 1. As such, its interior wall surface is coated with a layer of insulation material. A further liner section **52***f* is connected to the top of the section **52***d* by a further swage member **52***g*. The upper end of the upper section **52***f* is connected to further liner sections which extend to the surface of the earth, the upper end of the liner string **52** being secured to the wellhead equipment.

In the FIG. 3 embodiment, the production tubing string is indicated at **55.** Connected to the lower end thereof is a sealing assembly **56** which is of the same form of construction as the sealing assembly **20** of FIG. 1. This sealing assembly **56** is connected to the lower end of the tubing string **55** by way of a locator sub **57.** In this case, the locator sub **57** locates the lower end of the sealing assembly **56** by coming into contact with the shoulder in the swage member **52***g*. As indicated by cement **58,** both the casing string **50** and the liner string **52** are cemented into place.

The sealing mechanism provided by the liner string receptacle member **52***d* and the cooperating sealing assembly **56** functions in the same manner as that described for the sealing mechanism of FIG. 1. This sealing mechanism provides a high quality fluid seal between the liner string **52** and the tubing string **55.** It eliminates the need for the setting of a production packer and considerably facilitates later re-entry into the lower portion of the liner string **52** for workover purposes.

While there have been described what are at present considered to be preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, intended to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A method of completing oil and gas well boreholes drilled into the earth comprising the steps of:

lowering casing into the upper part of the borehole;

connecting an elongated tubular receptacle member into a string of production liner, such receptacle member having its interior wall surface coated with a layer of insulation material;

lowering the production liner and receptacle member into the borehole through the casing until a substantial portion of the production liner extends into the lower part of the borehole below the lower end of the casing;

cementing the casing, production liner and receptacle member in place in the borehole;

connecting a sealing assembly to the lower portion of a string of removable production tubing, such sealing assembly including a series of exteriorly located annular packing seal units having a maximum uncompressed outside diameter which is greater than the inside diameter of the receptacle member;

lowering the production tubing into the casing and placing the packing seal unit portion of the sealing assembly inside of the receptacle member; and

securing the production tubing to the wellhead equipment.

2. A method in accordance with claim 1 wherein the sealing assembly is run into the receptacle member until the lower end of the sealing assembly is adjacent the lower end of the receptacle member, the production tubing being secured to the wellhead equipment with the sealing assembly in this position.

3. A method in accordance with claim 1 wherein the receptacle member is connected to the top portion of the production liner string and the upper end of the production liner string is mechanically secured to the interior wall of the casing near the lower end thereof by means of a liner hanger mechanism.

4. A method in accordance with claim 1 wherein the receptacle member is connected into the production liner string at an intermediate point therein and the length of the production liner string is increased so that such string extends from the lower part of the bore hole below the lower end of the casing to the wellhead equipment located at the surface of the earth, the upper end of the production liner string being secured to the wellhead equipment after such string is positioned in the borehole.

5. Apparatus for producing hydrocarbons from a borehole drilled into the earth comprising:

a permanent production liner cemented into place in the borehole;

an elongated tubular receptacle member connected to the production liner and cemented into place in the borehole, such receptacle member having its interior wall surface coated with a layer of insulation material;

a string of removable production tubing suspended in the borehole;

a tubular support member connected to the lower portion of the string of production tubing and having an outside diameter which is less than the inside diameter of the receptatcle member;

and a series of annular packing seal units exteriorly mounted on the support member and having a maximum uncompressed outside diameter which is greater than the inside diameter of the receptatcle member;

the production tubing being suspended such that the packing seal units are positioned within the receptacle member for providing a fluid seal between the production liner and the production tubing and for enabling a substantial longitudinal expansion and contraction of the production tubing without breaking this fluid seal.

6. Apparatus in accordance with claim 5 wherein the production liner extends over the lower part of the borehole and wherein the apparatus further includes a casing extending over the upper part of the borehole and cemented into place therein and a liner hanger mechanism connected to the upper end of the production liner and mechanically securing same to the interior wall of the casing near the lower end thereof and wherein the receptacle member is connected to the top of the liner hanger mechanism.

7. Apparatus in accordance with claim 5 wherein the production liner extends from the surface of the earth to the lowermost hydrocarbon producing level in the borehole and wherein the receptatcle member is connected into the production liner string at an intermediate point which is above the highest known hydrocarbon producing level in the borehole.

8. Apparatus in accordance with claim 5 wherein the length of the receptacle member is in the range of twenty to forty feet.

9. Apparatus in accordance with claim 5 wherein the receptacle member is approximately thirty feet in length.

10. Apparatus in accordance with claim 5 wherein the insulation material on the interior wall of the receptacle member is a fluorocarbon plastic material.

11. Apparatus in accordance with claim 5 wherein the insulation material on the interior wall of the receptacle member is Teflon.

12. Apparatus in accordance with claim 5 wherein the inside diameter of the receptatcle member is at least as large as the inside diameter of the smallest diameter portion of the production liner.

13. Apparatus in accordance with claim 5 wherein the annular packing seal units are mounted in spaced-apart recesses formed in the outer portion of the support member and each packing seal unit comprises a plurality of annular sealing rings which are stacked against one another.

14. Apparatus in accordance with claim 5 wherein the annular packing seal units are mounted in spaced-apart recesses formed in the outer portion of the support member and wherein each packing seal unit comprises at least six annular chevron type sealing rings which are stacked against one another, a first annular adapter ring positioned against the sealing ring at one end of the stack and a second annular adapter ring positioned against the sealing ring at the outer end of the stack, these adapter rings cooperating with the ends of the recess for maintaining the sealing rings in a proper operating orientation.

15. Apparatus in accordance with claim 14 wherein the sealing rings are formed of a composition comprising a mixture of fluoroelastomer material and asbestos and the adapter rings are formed of a fluorocarbon plastic material.

16. Apparatus for uise in completing oil and gas wells comprising:

an elongated tubular recepttacle member adapted to be permanently connected into a string of permanent production liner and having its interior wall surface coated with a layer of insulation material;

a tubular support member adapted to be connected to the lower portion of a string of removable production tubing and having an outside diameter which is less than the inside diameter of the receptatcle member;

and a series of annular packing seal units extreiorly mounted on the support member and having a maximum uncompressed outside diameter which is greater than the inside diameter of the receptacle member;

the portion of the support member on which the packing seal units are mounted being adapted to be positioned within the receptacle member for cooperating with same for providing a fluid seal between the production liner and the production tubing and for enabling a substantial longitudinal expansion and contraction of the production tubing without breaking this fluid seal.

17. Apparatus in accordance with claim 16 wherein the length of the receptacle member is in the range of twenty to forty feet.

18. Apparatus in accordance with claim 16 wherein the receptacle member is approximately thirty feet in length.

19. Apparatus in accordance with claim 16 wherein the insulation material on the interior wall of the receptacle member is a fluorocarbon plastic material.

20. Apparatus in accordance with claim 16 wherein the insulation material on the interior wall of the receptable member is Teflon.

21. Apparatus in accordance with claim 16 wherein the insulation material on the interior wall of the receptacle member is polytetrafluoroethylene material.

22. Apparatus in accordance with claim 16 wherein the insulation material on the interior wall of the receptacle member is fluorinated ethylene-propylene material.

23. Apparatus in accordance with claim 16 wherein the interior wall of the receptacle member is machined and polished and the layer of insulation material is coated onto this polished surface.

24. Apparatus in accordance with claim 16 wherein the inside diameter of the receptacle member is at least as large as the inside diameter of the smallest diameter portion of the production liner string to which it is to be connected.

25. Apparatus in accordance with claim 16 wherein the maximum outside diameter of the support member is at least 0.04 of an inch less than the inside diameter of the layer of insulation material coated on the interior wall of the receptacle member.

26. Apparatus in accordance with claim 16 wherein the annular packing seal units are spaced apart along the support member and each such packing seal unit comprises a plurality of annular sealing rings.

27. Apparatus in accordance with claim 26 wherein there are at least six annular packing seal units on the support member.

28. Apparatus in accordance with claim 26 wherein there are from six to ten packing seal units on the support member.

29. Apparatus in accordance with claim 16 wherein the annular packing seal units are mounted in spaced-apart recesses formed in the outer portion of the support member.

30. Apparatus in accordance with claim 29 wherein each annular packing seal unit comprises a plurality of annular sealing rings which are stacked against one another.

31. Apparatus in accordance with claim 30 wherein the sealing rings are constructed to have an approximately chevron shaped cross-section.

32. Apparatus in accordance with claim 31 wherein the sealing rings are formed of a composition comprising a mixture of fluoroelastomer material and asbestos.

33. Apparatus in accordance with claim 16 wherein the annular packing seal units are mounted in spaced-apart recesses formed in the outer portion of the support member and wherein each packing seal unit comprises at least six annular chevron type sealing rings which are stacked against one another, a first annular adapter ring positioned against the sealing ring at one end of the stack and a second annular adapter ring positioned against the sealing ring at the other end of the stack, these adapter rings cooperating with the ends of the recess for maintaining the sealing rings in a proper operating orientation.

34. Apparatus in accordance with claim 33 wherein the sealing rings are formed of a composition comprising a mixture of fluoroelastomer material and asbestos and the adapter rings are formed of a fluorocarbon plastic material.

35. Apparatus in accordance with claim 16 wherein the length of the receptacle member is in the range of twenty to forty feet, the insulation material on the interior wall of the receptacle member is a fluorocarbon plastic material, the interior wall of the receptacle member is machined and polished and the layer of fluorocarbon plastic material is coated onto this polished surface and the inside diameter of the receptacle member is at least as large as the inside diameter of the smallest diameter portion of the production liner string into which it is to be connected and wherein the maximum outside diameter of the support member is at least 0.04 of an inch less than the inside diameter of the layer of fluorocarbon plastic material coated on the interior wall of the receptacle member and wherein the annular packing seal units are mounted in spaced-apart recesses formed in the outer portion of the support member and each such packing seal unit comprises at least six annular chevron type sealing rings which are stacked against one another, a first annular adapter ring positioned against the sealing ring at one end of the stack and a second annular adapter ring positioned against the sealing ring at the other end of the stack, the sealing rings being formed of a composition comprising a mixture of fluoroelastomer material and asbestos and the adapter rings being formed of a fluorocarbon plastic material.

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U.S. Cl. X.R.

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