Jan. 20, 1970 H. D. NETTLES 3,490,525

WELL BLOW-OUT PREVENTER AND TESTING APPARATUS

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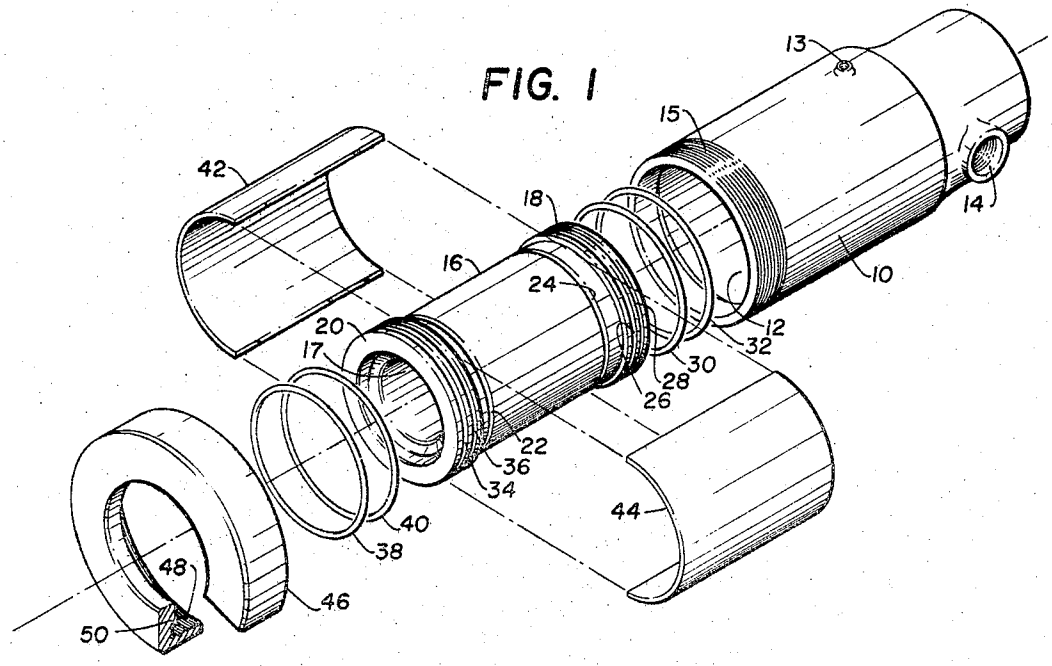
FIG. 1



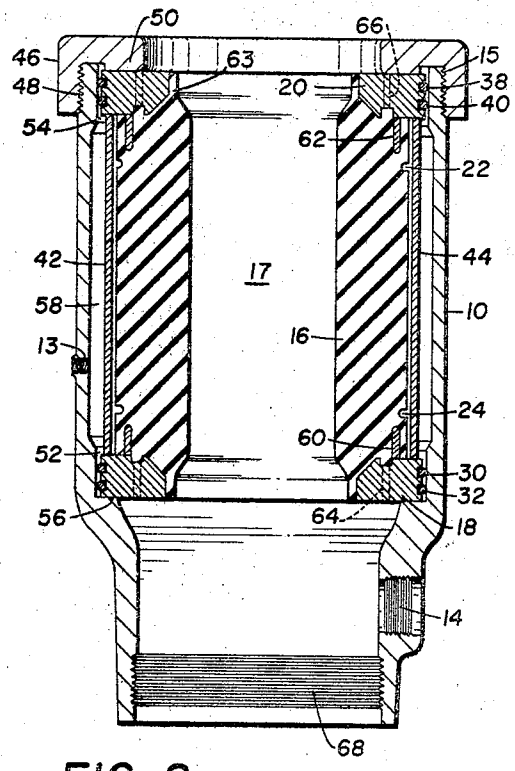


FIG. 2

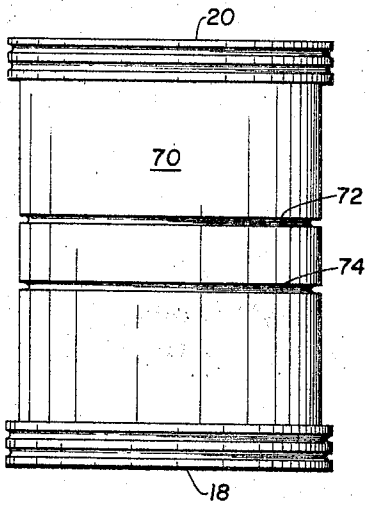


FIG. 3

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WELL BLOW-OUT PREVENTER AND TESTING APPARATUS

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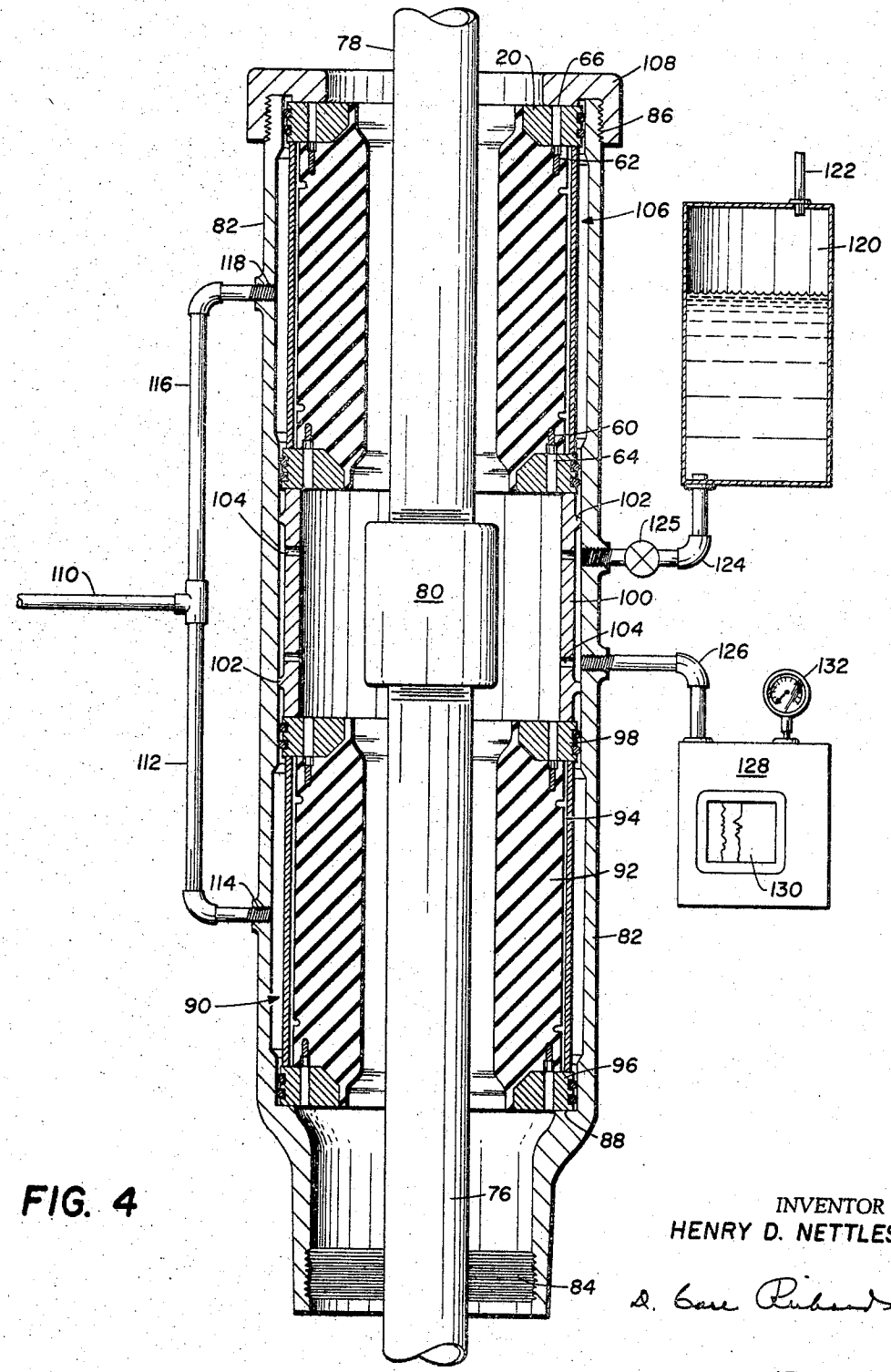

FIG. 4

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WELL BLOW-OUT PREVENTER AND TESTING APPARATUS

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Continuation-in-part of application Ser. No. 436,742, Mar. 3, 1965. This application Mar. 27, 1967, Ser. No. 626,317

Int. Cl. E21b *33/06, 33/126*

U.S. Cl. 166—97

19 Claims

ABSTRACT OF THE DISCLOSURE

A well blow-out preventer including a rigid well head forming a chamber encompassing a packer insert having a radially deformable sleeve molded between a pair of flat disks with a pair of segmented spacer plates disposed between the two disks to maintain a predetermined spacing between the disks during the application of fluid pressures which radially deform the sleeve. A pair of the inserts may be spaced apart in a common chamber to facilitate treating and testing of elongated members extending into a well.

RELATED APPLICATIONS

This application is a continuation-in-part of applicant's copending application, Ser. No. 436,742, filed Mar. 3, 1965, entitled "Pressure Chamber for Continuous Testing or Treating of Tubular Goods," and now abandoned.

FIELD OF THE INVENTION

This invention relates to a packer apparatus for use in an oil well environment and more particularly to a packer apparatus for providing a fluid-tight seal in a well for use as a blow-out preventer, a master valve, a wiper or the like. In a further aspect, this invention relates to apparatus for testing and treating elongated objects extending into a well.

DESCRIPTION OF THE PRIOR ART

In operations connected with the drilling of or the production of fluids from wells leading from the surface of the earth to subsurface earth formations, it is often necessary to insert or withdraw long strings of tubular goods, to insert or withdraw elongated rod-type elements, or to insert or withdraw items of equipment by means of a wire cable. Such insertion or withdrawal of items from the well often needs to be carried out after the well has been cased with an enlarged tubular casing, to control the formation forming the walls of the well, and when a fluid, emanating from a subsurface earth formation, is present under pressure in the casing. Accordingly, it is necessary, when inserting or withdrawing equipment from the well, to seal the annular space between the casing and the pipe, rod or cable being inserted or withdrawn to prevent such fluid from blowing out the top of the casing.

Such sealing has heretofore been effected by various types of resilient sleeves which clamp against the item being inserted or withdrawn while, at the same time, forming a seal against the internal wall of the casing. These sealing means are generally referred to as blow-out preventers and may be forced into sealing relationship by mechanical pressure between the various parts of the mechanism or by hydraulically expanding the resilient sleeve with a liquid or gas under pressure. It is the hydraulically-actuated type of blow-out preventer to which one aspect of the present invention is directed.

Such hydraulically-actuated blow-out preventers are difficult and expensive to manufacture, since it is a real

problem to try to expand a resilient element tightly about a pipe or rod substantially smaller in diameter than the internal diameter of the sleeve while, at the same time, retaining a good seal against the walls of the casing surrounding the blow-out preventer. This problem is generally solved by trying to hit a happy medium between two extremes. If the resilient element is made sufficiently soft and pliable to form a tight seal about the tubing or rod passing through its interior, the preventer will have a tendency to readily pull away from the walls of the casing. On the other hand, if the resilient portion of the blow-out preventer is made sufficiently rigid that the problem of the preventer pulling away from the casing wall does not occur, the resilient portion is generally too rigid to form a good seal about the pipe or rod passing through its center.

Accordingly, a majority of blow-out preventers are a compromise between these two extremes. For example, the U.S. Patent No. 2,035,925 requires not only a plurality of threaded pins set in fastening rings imbedded in each end of the resilient portion of the preventer to eliminate pulling away from a casing well seal, but also requires a circular series of radial plates set in the resilient portion to prevent excessive deformation. Such preventers have often not been totally satisfactory with respect to the effectiveness of a well pipe seal, and further have not allowed the device to be used as a master valve by allowing the resilient portion to completely close off the well casing. In addition, many previously developed blow-out preventers generally require a separate sealing mechanism to provide a seal between the blow-out preventer and the interior of the casing. A preventer of this general type is shown in U.S. Patent No. 2,465,848. The problem of sealing about the exterior of the rubber sleeve is quite obvious from an observation of the movement of this type blow-out preventer. To overcome this problem, it has also been proposed that one end of the preventer sleeve be anchored while the other end is free to move. A piston-type movement results and a seal with the casing wall is formed by a ring as in any other type of piston. This approach is illustrated in U.S. Patent No. 2,945,665. Here again, packers or blow-out preventers of the type described in the latter patent are not only expensive to manufacture, but the seal provided by the piston-type end is generally not satisfactory for many purposes. There are also certain operations, as will be hereinafter discussed, which require maintaining a constant volume of fluid in a given space, and blow-out preventers which vary the volume of the space adjacent the preventer are unsatisfactory in such operations.

In addition to the above, whether there is fluid under pressure in the well casing or not, it is necessary, when production tubing is placed in the well, to pressure test the connections between individual sections of the tubing in a manner generally shown by U.S. Patent No. 2,761,-311. However, such testing has generally required complex gate configurations to prevent extrusion of the resilient sleeves from the main housing, and have often not provided the convenience and economy of operation required in practical tubing testing.

Also, in connection with the running of production tubing into a well, it is often necessary to treat the tubing with various materials, such as corrosion inhibitors. However, no completely convenient or effective means has heretofore been proposed for carrying out such treatment while the tubing is being run. Instead, such treatment is often either applied to individual sections of tubing before coupling the sections together and before running them in the well, or by circulating a fluid in the annular space between the casing and the tubing after the tubing has been run in the well. In the latter case,

fluids in the annular space between the casing and the tubing interfere with proper treatment of the tubing and excessive amounts of treating material are needed.

SUMMARY

In accordance with the present invention, a well head is provided with a cylindrical bore housing a packer insert which includes a pair of spaced rigid disks having outer diameters for establishing a pressure seal with the walls of the cylindrical bore. A radially deformable sleeve is molded at its ends to the disks. A longitudinally segmented rigid cylinder is disposed between the disks to maintain spacing therebetween upon application of fluid pressure. In another aspect of the invention, a pair of such packer inserts are spaced apart to form an annular chamber for testing or treating tubing in a well bore.

THE DRAWINGS

Other objects and intended advantages of this invention will be more readily apparent by the references to the following detailed description in connection with the accompanying drawings wherein:

FIGURE 1 is an expolded view of an embodiment of the present device;

FIGURE 2 is a cross-sectional view of the assembled device shown in FIGURE 1;

FIGURE 3 is a side view of another embodiment of a packer insert according to the present invention; and

FIGURE 4 is a cross-sectional view of a tubing testing and treating chamber embodying the present invention.

THE PREFERRED EMBODIMENTS

Referring now to the drawings, wherein like reference numbers refer to like and corresponding parts throughout the several figures, FIGURE 1 illustrates a main housing or well head **10** comprising an integral cast metal body having a cylindrical bore **12** which defines a chamber for receiving the packer insert. A fluid inlet **13** extends through the side of the housing **10** and may include suitable threads for connection to a conventional source of fluid pressure. A port **14** in one end of the head **10** allows passage of oil therethrough when desired, or allows the connection of a pressure gauge or the like. A threaded portion **15** enables head **10** to be connected to a standard casing or tubing.

The packer insert comprises a deformable elastomeric sleeve **16**, preferably molded from rubber, which has a center opening **17** and which is permanently molded at the ends to confronting faces of the flat rigid disks **18** and **20**. A pair of spaced apart grooves **22** and **24** are formed in the outer periphery of the sleeve **16** in order to establish an area of greatest flexibility. A pair of grooves **26** and **28** are disposed about the edge of disk **18** to receive suitable O-ring seals **30** and **32**. Similarly, grooves **34** and **36** are disposed about the exterior edge of disk **20** for respectively receiving O-rings **38** and **40**.

A rigid metallic cylinder is longitudinally sliced or segmented to form spacer plates **42** and **44**. Plates **42** and **44** fit between disks **18** and **20** and encompass the sleeve **16** to maintain the desired spacing between the disks. This assists in maintaining the sealing ability of the packer device, during application of severe fluid pressures through inlet **13**.

An end ring **46** includes an inner threaded portion **48** for connection with the threaded portion **15** of the head **10**. A radially inwardly extending flange **50** forms a shoulder which abuts the top face of the disk **20** during assembly in order to longitudinally compress the packer unit inside the housing **10**.

FIGURE 2 shows the assembled blow-out preventer wherein the head **10** has a cylindrical bore which is relieved annularly to form two cylindrical landings **52** and **54**. A cylindrical shoulder **56** is also defined in the main housing **10** for abutment with a face of the disk **18**. The diameter of disk **18** is but slightly smaller than the diameter of the cylindrical bore of the head **10** so that the

O-rings **30** and **32** provide a fluid-tight seal against the landing **52**. The center opening of disk **18** is large enough to accommodate tubing and tubing couplings.

The relieved portion **58** of the main housing **10** allows the packing unit to be easily inserted or withdrawn from the head **10** by minimizing the contact area. The center opening of disk **20** is generally equal to and aligned with the center opening of disk **18**.

The unitary molded construction of the packer unit may be best understood by reference to the cross-sectional view of the disks **18** and **20** shown in FIGURE 2, wherein annular projections **60** and **62** may be seen to extend longitudinally into the flexible sleeve **16** in order to provide a bond of enhanced strength. Additionally, the sleeve **16** is provided with lips **63** molded over a portion of the disk faces in order to strengthen the bond. A plurality of holes **64** and **66** may be respectively bored at suitable spaced intervals around the disks **18** and **20** to allow injection of fluid elastomeric material therethrough during the molding process. By completely molding elastomeric material around the irregularly shaped confronting faces of the disks **18** and **20**, the present invention provides a superior unitary packer unit which may be easily inserted into the head **10** or replaced when necessary.

Standard interior threads **68** are provided at the lower end of the main head **10** for connection with standard well casing or tubing. The outlet port **14** also includes threaded connections so that suitable outlet flow lines or the like may be connected to the device for passage of oil therethrough when the deformable sleeve is sealed.

The assembled device thus presents a central opening **17** for passage of well tubing therethrough. The interior end portions of the sleeve **16** are radially inwardly tapered to guide the insertion of the tubing. When a fluid-tight seal is desired about the exterior of tubing, the tubing is inserted and fluid under pressure from a suitable source is applied through the port **13** into the space defined between the relieved portion **58** of the main housing **10** and the deformable sleeve **16**. The segmented spacer plates **42** and **44** do not completely span the periphery of the sleeve so that fluid will flow around the ends of the spacers radially to force the sleeve **16** against the tubing. If desired, additional suitable openings may be formed through the spacers **42** and **44** for flow of fluid to the exterior of the sleeve **16**. The cross section of the sleeve **16** is shaped so that coupling sleeves of varying diameters pass through the present insert without necessitating the use of complicated locking or release means. The extreme strength of the unitary packer unit construction allows a fluid-tight seal to be maintained even during movement of well tubing through the opening **17**.

The grooves **22** and **24** defined about the exterior of deformable sleeve **16** perform the useful purpose of defining the area of greatest deformation of the sleeve upon the application of fluid pressure. In the example illustrated, the region of the sleeve between the grooves **22** and **24** would thus primarily move against the exterior of tubing inserted through the device. Additionally, the sleeve **16** can be constructed to be flexible enough to completely seal off a well pipe end which is fixed to the threaded connections **68** by completely closing off the central passage **17**. In such an application, the regions of the flexible sleeve **16** between the grooves **24** and **22** woul close against each other and actually ride up or "cold flow" upwardly for a short distance relative to the main housing **10**. Due to the strength of the molded bond between the sleeve **16** and the disks **18** and **20**, such movement does not affect the structural integrity of the device.

FIGURE 3 illustrates another embodiment of the packer unit **70** wherein grooves **72** and **74** are disposed about the deformable elastomeric sleeve in the center region of the sleeve length, or preferably within the middle one-third of the sleeve. This central region of the

sleeve between the grooves **72** and **74** would be primarily deformed upon the application of fluid pressure. By reducing the area of greatest deformation of the sleeve, it will be readily seen that a greater sealing pressure may be exerted upon an inserted well tubing for a given fluid pressure. Other spacings of the grooves may, of course, be utilized in accordance with the desired characteristics of a particular device.

FIGURE 4 illustrates a combination utilizing the present invention in the pressure testing and treating of a string of pipe passing into a well casing. A string of tubing having a lower joint **76** and an upper joint **78** is connected by a suitable sleeve-type coupling **80**. One of the primary purposes of this aspect of the present invention is to test coupling **80** for fluid leaks where the coupling connects joints **76** and **78**.

Accordingly, the main body of the testing and treating unit of the present invention is provided by an appropriate section of high-test pressure casing **82**, which carries a lower threaded end **84** which may be connected to the well casing and an upper threaded end **86**. An annular shoulder **88** is formed in the lower end of the casing **82** to abut a lower portion of a packer insert **90** which is utilized as a blow-out preventer to prevent fluid under pressure in the well casing from blowing out the top of the well while the tubing string is being inserted in the well or being pulled from the well. The packer insert **90** is constructed substantially in accordance with the insert unit previously described with reference to FIGURES 1 and 2, and consequently will not be described in detail except as to one difference having to do with the location of the ports **64** and **66** relative to the rings **60** and **62**. In this embodiment, the ports **64** and **66** are centered on the rings **60** and **62**, respectively. The hole **66** is bored through disk **20** and down into the ring **62**, preferably at least one diameter below the bottom of disk **20** so that there may be flow through port **66** from both sides of ring **62**. This facilitates escape of air from the top of a mold during injection of the rubber and aids in assuring a reliable bond between the rubber and the ring **62**. In a similar manner, the hole **64** is located as to emerge on both sides of the ring **60**. The lower packer of FIGURE 4, as well as the packer of FIGURE 1, similarly may be constructed in accordance with a preferred embodiment of the invention.

As in the previously described packer insert, the blow-out preventer **90** includes a deformable rubber sleeve **92** adapted to be radially deformed upon the application of fluid pressure to form a fluid-tight seal about the exterior of joint **76**. The blow-out preventer **90** also includes a longitudinally segmented spacer cylinder **94** which spaces apart the disks **96** and **98** which are molded to opposite ends of the sleeve **92** to form a unitary packer insert which may be easily inserted or removed from the casing **82**. In a manner similar to that previously described, the walls of the casing **82** may be relieved to further facilitate insertion and retraction of the packer unit. O-ring seals provide fluid-tight seals against the disks **96** and **98** and the walls of the casing **82** in a manner previously disclosed.

A rigid, integral spacing cylinder **100** of a diameter less than the inner diameter of the casing **82** is inserted into the casing **82** flush against the top of the disk **98**. The cylinder **100** is provided with a plurality of spacing projections **102** which provide a small annular space between the sides of cylinder **100** and the interior wall of the casing **102**. The cylinder also includes a plurality of perforations **104** which allow the passage of fluid therethrough in a manner to be subsequently described.

Also inserted into the chamber **82** after insertion of the cylinder **100** is a second blow-out preventer **106** constructed in an identical manner as the lower blow-out preventer **90**. An annular end ring **108** is provided with threads for connection with the threaded portion **86** of the casing **82** to longitudinally secure the two blow-out preventers **90** and **106** and the spacing cylinder **100** within the casing **82**.

Fluid under pressure from an appropriate source (not shown) may be provided through the conduits **110** and **112** through a port **114** defined in casing **82** in order to radially deform the sleeve **92** and provide a fluid-tight seal about the lower joint **76**. Similarly, fluid may be provided through the conduits **110** and **116** through a port **118** in order to deform the deformable sleeve of the second blow-out preventer **106** about the upper joint **78**. This effectively isolates an interior section of the tubing string in a chamber formed between the two actuated blow-out preventers to allow the testing or treating of the isolated tubing section.

A surge tank **120** contains a body of liquid under pressure by a pressurized gas, supplied through supply line **122**. The liquid in the surge tank **120** may be supplied to the testing and treating chamber defined within the casing **82** through a fluid line **124**, valve **125**, and through the perforations **104** in the cylinder **100**. A fluid outlet **126** also in fluid communication with the testing and treating chamber is connected to a pressure responsive meter **128**. A recorder **130** may provide a permanent record of the pressure within the testing chamber and a gauge **132** may provide a visual indication of the conditions within the chamber.

In operation, the two blow-out preventers and the spacing cylinder are secured within the casing **82** and then the tubing string is run through the unit through the axial openings of the two blow-out preventers. The blow-out preventers are actuated by any fluid under appropriate pressure, preferably, for reasons of safety and economy, carbon dioxide under pressure. With the blow-out preventers thus actuated, the tubing string may be moved through the testing and treating space without permitting fluid to escape from the casing below or from the testing and treating chamber.

In order to test the coupling **80** for leaks, fluid, or gas such as carbon dioxide, is maintained within the testing chamber at a substantially constant pressure. Under these circumstances, any leak in the coupling **80** may be observed and recorded by the meter **128**. Any significant or sudden change in pressure due to leaks in the coupling may be observed on the pressure gauge **132** and recorded by the recorder **130**.

By utilizing a liquid in the chamber defined between the two blow-out preventers, it is also possible to continuously treat the tubing string with appropriate treating agents as the tubing string is being run into a well. For example, it is often highly desirable to treat the exterior surface of the tubing with an appropriate corrosion inhibitor before the tubing is run into the well. Additionally, it may be desirable to apply a lubricant material to the tubing string being run into the well in a similar manner.

Having described the invention in connection with certain specific embodiments thereof, it is to be understood that further modifications may now suggest themselves to those skilled in the art and it is intended to cover such modifications as fall within the scope of the appended claims.

What is claimed is:

1. A well packer apparatus for use in a well head unit having a cylindrical bore therethrough defining two spaced apart cylindrical bearing surfaces and two opposed abutment shoulders, which comprises:

(a) a pair of spaced apart disks having aligned center openings and an outer diameter less than said cylindrical bore,

(b) a radially deformable elastomeric sleeve molded at each end to the confronting faces of said disks having an outer diameter less than the diameter of said chamber and forming with said disks a unitary body of length corresponding with the distance between said shoulders, said elastomeric sleeve having

a central opening therethrough and being sufficiently radially deformable for completely closing off of said central opening, and

(c) a longitudinally segmented rigid cylinder of the length of said sleeve adapted to encompass said sleeve when disposed between said disks to maintain the desired spacing between said disks.

2. A well packer unit which comprises:

(a) a well head to be secured to the mouth of a well casing and having a cylindrical bore reentrant to form a landing shoulder facing the end of said well head opposite said casing,

(b) a pair of rigid rings and a radially deformable elastomeric sleeve molded between said rings to form a unitary insert of length approximating the distance from said shoulder to said end, and including means for sealing said rings with the walls of said well head adjacent to said shoulder and adjacent to said end, said sleeve being of outer diameter smaller than the diameter of said rings and having a central aperture therethrough, said sleeve being sufficiently radially flexible to completely seal off said central aperture upon the application of fluid pressure thereto,

(c) a longitudinally segmented rigid cylinder encompassing said sleeve and abutting said rings to maintain a predetermined spacing between said rings, and

(d) an apertured cap engaging said end of said head and one of said rings to force the other of said rings against said shoulder.

3. The apparatus of claim **2** wherein said cylindrical bore is relieved annularly to form a pair of spaced cylindrical landings, sealing means being disposed between the outer periphery of each of said disks and one of said landings.

4. The apparatus of claim **2** and further comprising fluid inlet means defined in said well head for introducing fluid into the space between said unit and said elastomeric sleeve to radially deform said sleeve.

5. The apparatus of claim **1** wherein at least one groove is defined about the outer periphery of each of said disks, and annular flexible seal means is disposed in each of said grooves to maintain a fluid-tight seal between said disks and said bore.

6. The apparatus of claim **1** wherein each of said disks includes an annular projection for extending longitudinally into an end of said elastomeric sleeve.

7. The apparatus of claim **1** wherein a pair of spaced apart grooves are formed in the outer periphery of said elastomeric sleeve to define the area of greatest deformation of said sleeve.

8. The apparatus of claim **7** wherein said grooves are each respectively located near the region of an end of said sleeve.

9. The apparatus of claim **7** wherein both of said grooves are located in the near center region of the length of said sleeve.

10. In a well head having a chamber for receiving fluid pressure, the combination comprising:

(a) two spaced apart rigid disks having aligned center openings and outer diameters for fitting within said chamber,

(b) a radially deformable elastomeric sleeve having a central aperture therethrough and molded at each end to a confronting face of one of said integral disks to form a unitary packer insert for the chamber, said sleeve being sufficiently resilient to completely close off said central aperture upon the application of fluid pressure thereto, and

(c) a pair of half cylinders encompassing said sleeve and engaging in abutting relation the confronting faces of said disks.

11. The combination of claim **10** wherein a pair of spaced apart grooves are formed in the outer periphery of said sleeve to define a region of pronounced sleeve flexibility.

12. The combination of claim **10** wherein annular projections extend from each of said disks into the ends of said sleeve to enhance the bond between said disks and said sleeve.

13. The combination set forth in claim **10** wherein each of said disks includes an annular projection extending longitudinally into the ends of said sleeve and wherein ports extend through said disks in alignment with the centers of said projections and are of diameter to extend through both sides of said projections for escape of air from both sides thereof.

14. Apparatus for isolating an exterior section of an elongated member extending into a well bore, comprising:

(a) a tubular housing defining a chamber having an internal diameter larger than the maximum diameter of the elongated member and having an annular shoulder means therein,

(b) a pair of packer inserts longitudinally separated by a rigid spacer within said chamber to define a test zone between said inserts, each said insert including:

(c) a pair of spaced apart rigid disks having aligned center openings of a diameter larger than the maximum diameter of said member and outer diameters generally equal to the inner diameter of said chamber, one of said disks abutting said shoulder means,

(d) a radially deformable elastomeric sleeve molded at each end to the confronting faces of said disks and having an outer diameter less than the interior diameter of said chamber,

(e) a longitudinally segmented rigid cylinder encompassing said sleeve and disposed between said disks to maintain the desired spacing between said disks, and

(f) a cap engaging the mouth of said housing opposite said shoulder and engaging one of said disks to force said inserts and said spacer toward said shoulder.

15. The combination of claim **14** wherein said spacer comprises a cylinder of a diameter less than the inner diameter of said chamber and having perforations therethrough.

16. The combination of claim **14** wherein first fluid inlet means communicates with said test zone for applying test pressures to said member, and second fluid inlet means communicates with the zones between the disks of each of said packer inserts for radially deforming said sleeves against the elongated object in response to fluid pressure applied to said sleeves.

17. The combination of claim **14** wherein at least one groove is defined about the outer periphery of each of said disks, and annular flexible seal means are disposed at each of said grooves to maintain a fluid-tight seal between said disks and said chamber.

18. The combination of claim **14** wherein each of said disks includes an annular projection extending longitudinally into a molded end of said elastomeric sleeve.

19. The combination of claim **14** wherein a pair of spaced apart grooves are disposed about the outer periphery of each of said elastomeric sleeves to define an area of greatest sleeve deformation.

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JAN A. CALVERT, Assistant Examiner

U.S. Cl. X.R.

73—46; 251—1; 277—34, 214