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(54) **HYDROSTATIC-SET OPEN HOLE PACKER WITH ELECTRIC, HYDRAULIC AND/OR OPTICAL FEED THROUGHS**

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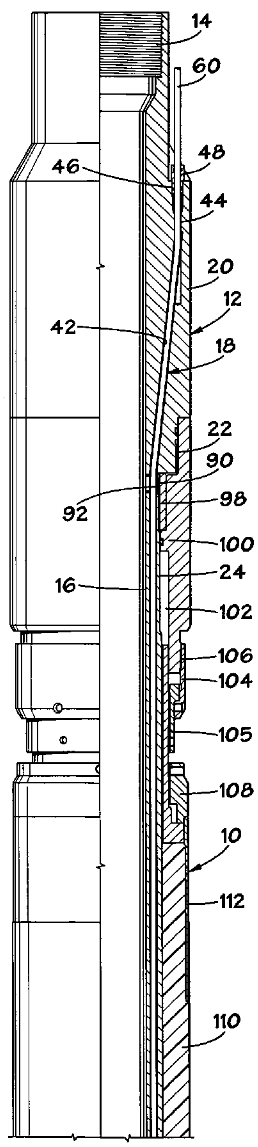
(57) **ABSTRACT**

Devices and methods are described for disposing electric, hydraulic and/or optical cables or conduits axially through a hydrostatically-set packer mechanism. Radial fluid communication is also provided through the inner mandrel so that the packer mechanism may be set using hydrostatic pressure within the flowbore. Feed-through paths for the cables or conduits isolate the cables/conduits from fluid pressure as well as axial or torsional tensile forces.



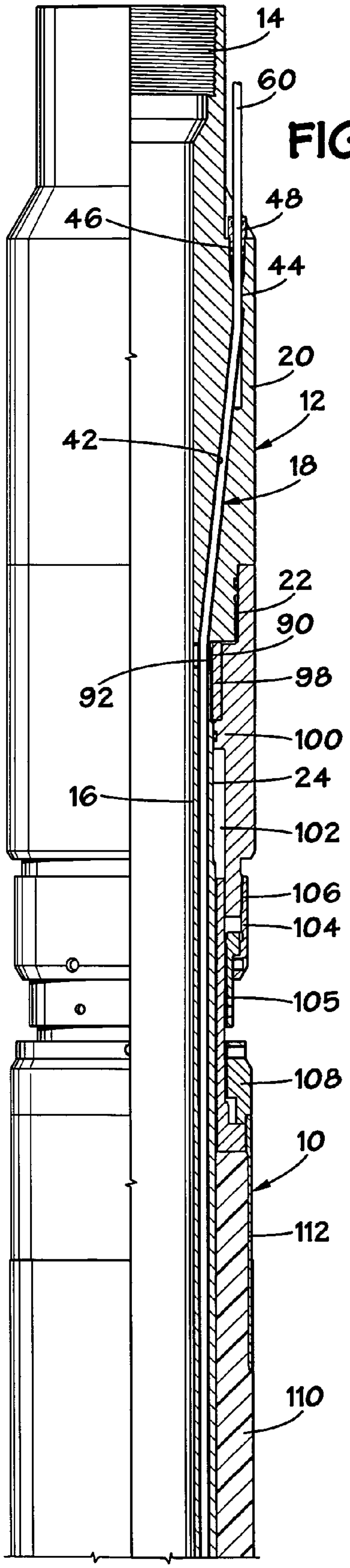

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FIG. 1A

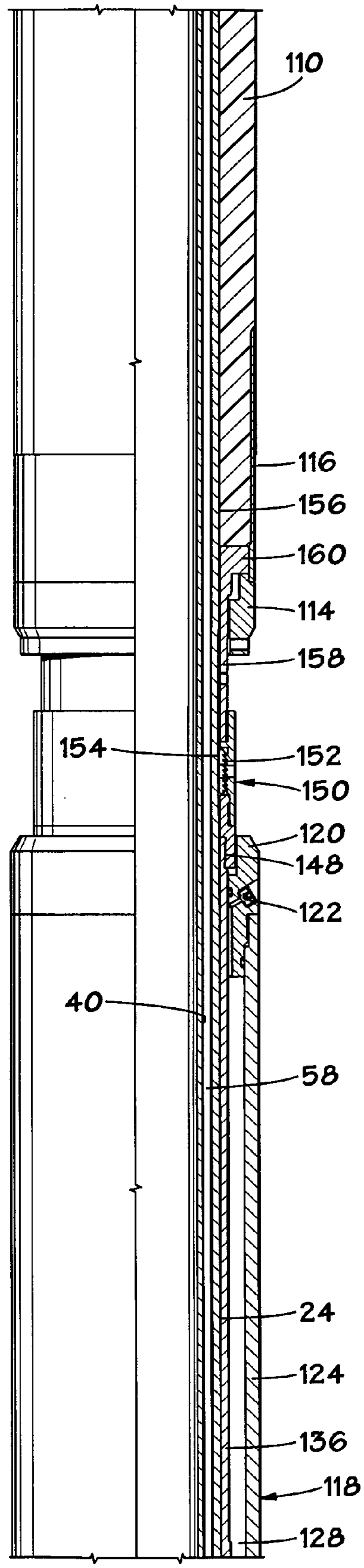
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FIG. 1B

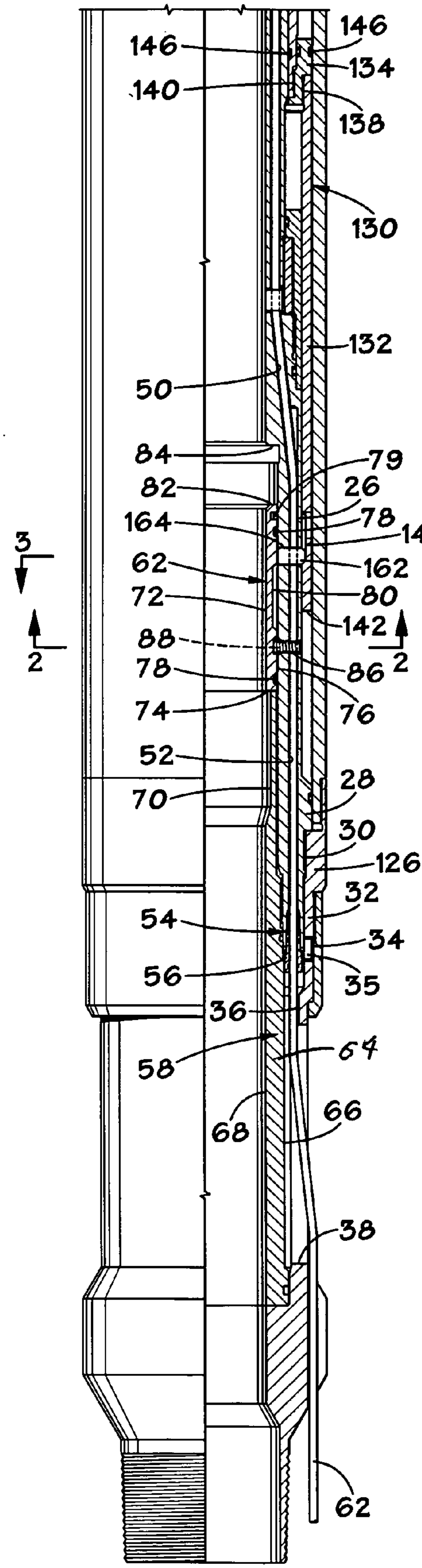

FIG. 1C

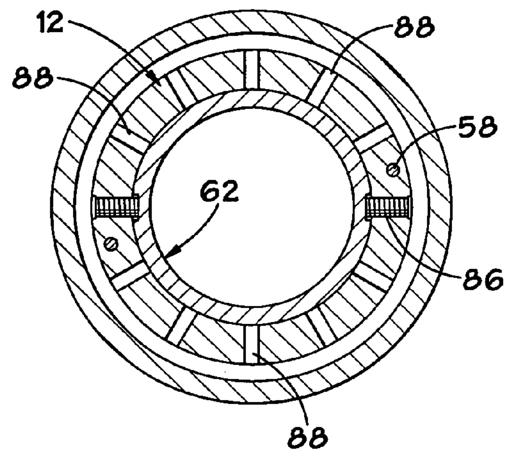

FIG. 2

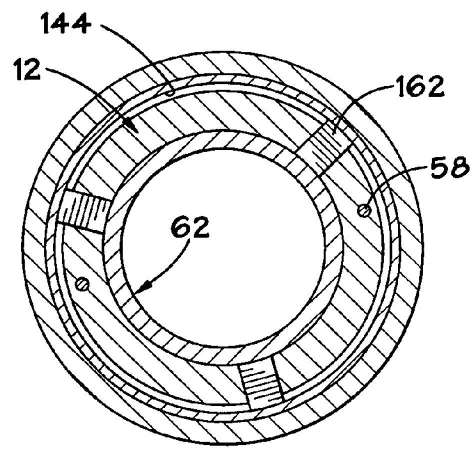

FIG. 3

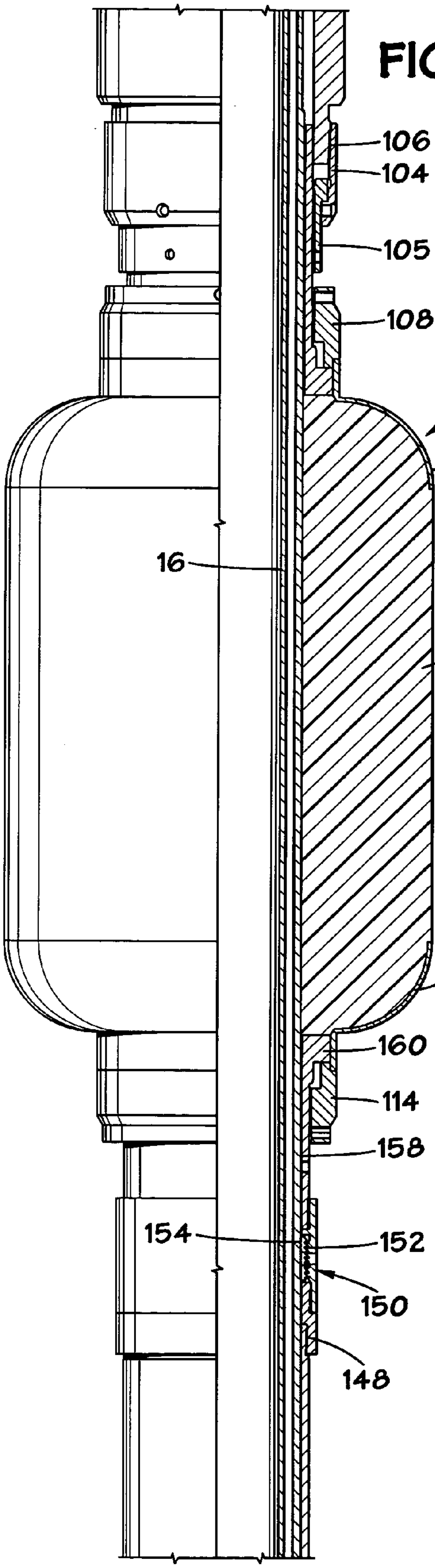
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FIG. 4A

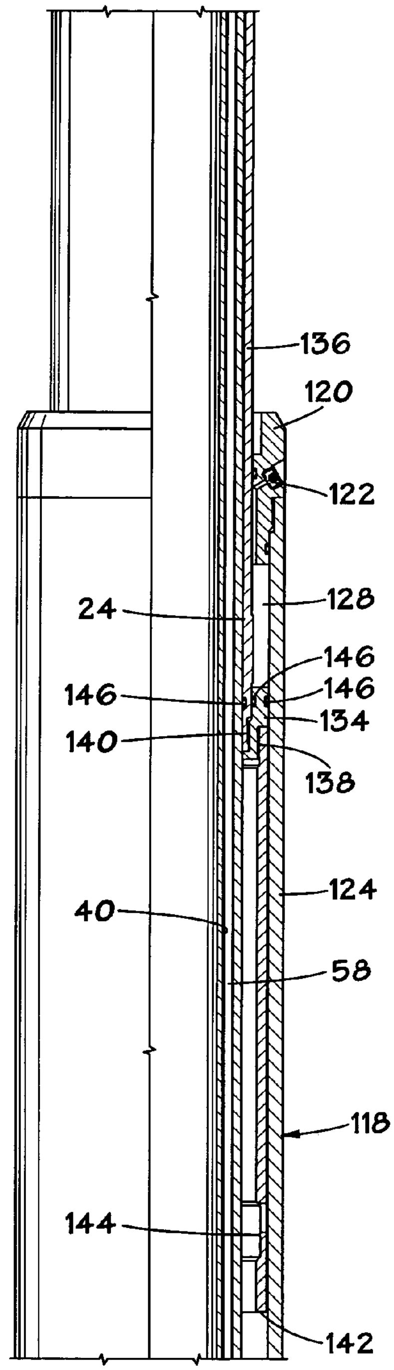
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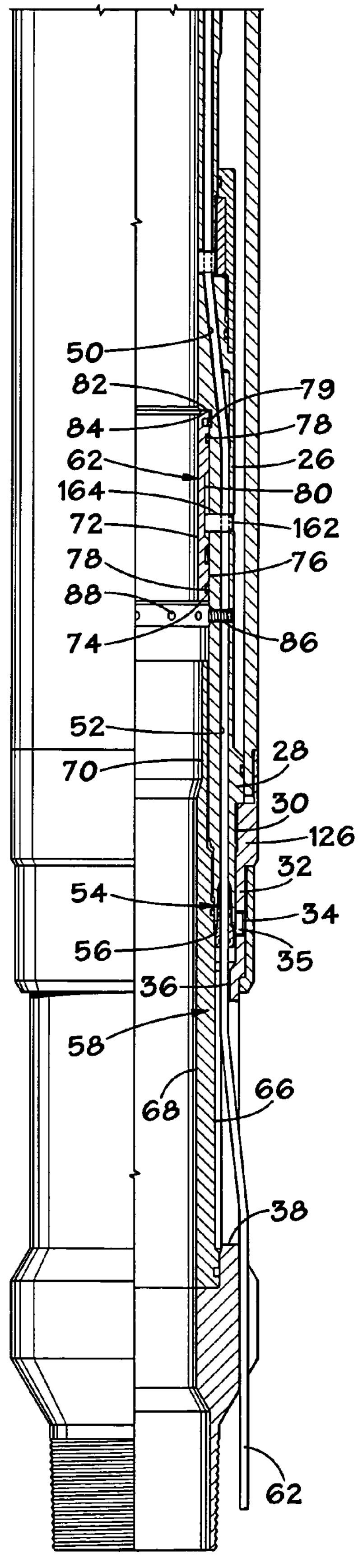
FIG. 4B

FIG. 4C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HYDROSTATIC-SET OPEN HOLE PACKER WITH ELECTRIC, HYDRAULIC AND/OR OPTICAL FEED THROUGHS

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The invention relates generally to the design of downhole packers and to mechanisms for passing cables and conduits through a packer. In particular aspects, the invention relates to the design of packers that are set using hydrostatic wellbore fluid pressure.

[0003] 2. Description of the Related Art

[0004] When installing a production string within a wellbore, it is often necessary to form a fluid seal within a large diameter opening, such as an open (uncased) hole. To accomplish this, a packer assembly is needed that can provide large radial expansion of the sealing element. Unfortunately, conventional large expansion packer systems generally lack the ability to pass electrical or fiber optic cables or fluid conduits axially through the packer assembly so that other devices may be used below the packer device.

[0005] The desirable requirements for a large diameter packer system are typically at odds with those for a conduit pass-through system. U.S. Pat. No. 6,220,362, issued to Roth et al. describes a pass-through conduit arrangement for a packer assembly or other tool. The Roth patent is owned by the assignee of the present invention and is incorporated herein by reference. Roth describes a system wherein one or more axial conduit passages are formed through an interior portion of a packer or other tool. Roth teaches that there be complete pressure isolation between the conduit and both the tubing and the annulus. However, Roth describes the use of a separate carrier 60 that lies radially within the tool mandrel 24 and is used to define the longitudinal passages for the conduits or cables. The potential exists for improper sealing between the carrier and mandrel during fabrication of the tool, leading to undesirable fluid entry into the longitudinal passages. Additionally, this design does not offer any means for radial communication of fluid outwardly from the flowbore of the tool to the radial exterior of the tool. In fact, the requirement that the longitudinal passages remain isolated from fluid pressure from the flowbore, as well as the annulus, dictates against penetration of the carrier and/or mandrel by a radial fluid communication passage. If the carrier and mandrel of this tool were perforated to allow radial fluid communication, the passages defined therebetween would undesirably become exposed to external wellbore fluid pressures.

[0006] To the inventor's knowledge, conduit feed through systems have not been successfully integrated into hydrostatically-set packer assemblies. It is believed that this failure is due to the complexity of a hydrostatic setting mechanism and the need for such a device to communicate hydrostatic fluid pressure through the inner mandrel of the packer assembly and into a chamber within the exterior portion of the packer assembly. The use of multiple interior pieces, such as a separate carrier and mandrel, to define a longitudinal cable/conduit pass-through, and the attendant assembly requirements, also adds to the difficulty of incorporating a cable feed-through feature into a hydrostatically-set device.

[0007] U.S. Pat. No. 6,842,315 issued to Coronado et al., describes a hydrostatically-set packer device having a composite sealing element with large radial expansion capabilities for use in through tubing and open hole applications. This patent is owned by the assignee of the present invention and is, therefore, incorporated by reference. The device of the '315 patent provides no feed-through arrangement for cables or conduits to be passed longitudinally through the packer device.

[0008] The present invention addresses the problems of the prior art.

SUMMARY OF THE INVENTION

[0009] The invention provides devices and methods for axially disposing electric, hydraulic and/or optical cables or conduits through the inner mandrel of a hydrostatically-set packer mechanism. In accordance with the devices and methods of the present invention, radial fluid communication is also provided through the inner mandrel so that the packer mechanism may be set using hydrostatic pressure within the flowbore. The axial feed-through path(s) for the cables or conduits are isolated from flowbore and annular fluid pressure. Additionally, the cables/conduits are protected from axial tensile forces and torsional forces that might damage them.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIGS. **1A-1C** present a side, cross-sectional view of an exemplary packer assembly with conduit feed through system constructed in accordance with the present invention.

[0011] FIG. **2** is an axial cross-section taken along lines **2-2** in FIG. **1C**.

[0012] FIG. **3** is an axial cross-section taken along lines **3-3** in FIG. **1C**.

[0013] FIGS. **4A-4C** present a side, cross-sectional view of the packer assembly shown in FIGS. **1A-1C**, now with the packer element having been set.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] FIGS. **1A-1C**, **2**, and **3** illustrate an exemplary hydrostatically-set packer assembly **10** that is constructed in accordance with the present invention. The packer assembly **10** includes a central mandrel **12** having an upper threaded end **14** which allows the packer assembly **10** to be incorporated into a production tubing string. The central mandrel **12** defines a central axial flowbore **16** along its length. A cable feed through path, generally designated as **18**, passes through the central mandrel **12**. Beginning at the upper end of the packer assembly **10**, the central mandrel **12** features a radially enlarged upper portion **20** with outer threads **22**. Below the enlarged upper portion **20** is a radially reduced mandrel portion **24**. At the lower end of the radially reduced portion **24** is a lower radially enlarged portion **26**. The enlarged portion **26** also defines an enlarged bore portion **27** within. The lower portion **26** presents an outwardly projecting shoulder **28** and a threaded connection **30** to a lower end sub **32**. The lower end sub **32** includes a set of interfitting longitudinal anti-rotation splines **34** and an axial cable passage **36**. The splines **34** engage complimentary splines **35** formed on the outside of the central mandrel **12**. Below the cable passage **36** is a lateral cable opening **38**.

[0015] In a currently preferred embodiment, the feed-though path **18** includes an axially-oriented longitudinal central portion **40** and an upper angled end portion **42** that extends from the upper end of the central portion **40** radially outwardly to an axial upper end passage **44**. The axial upper end passage **44** includes an enlarged bore **46** that is shaped and sized to accommodate end nut **48**. The lower end of the central portion **40** interconnects to a lower angled end portion **50** that extends radially outwardly to an axially-oriented lower portion **52**. The lower end of the lower portion **52** also has an enlarged bore **54** that is shaped and sized to accommodate an end nut **56**. It is noted that the feed-through path **18**, and all of its individual components **40**, **42**, **50**, **52**, are preferably constructed by drilling of suitably sized holes or passages through the central mandrel **12**. The component portions **40**, **42**, **50**, **52** should interconnect with one another axially to provide a continuous path. An exemplary cable **58** is shown disposed within the feed-through path **18** and secured therewithin by end nuts **48**, **56**. It can be seen that a portion **60** of the cable **58** extends upwardly toward the entry of the wellbore (not shown) while another portion **62** of the cable **58** extends downwardly toward a location below the packer assembly **10**. Thus, the cable feed-through path **18** allows communication through the packer assembly **10** to a device (not shown) that is located below the packer assembly **10**. It is noted that the term "cable," is used herein to refer to an electrical cable, a hydraulic fluid conduit, a fiber optic cable, or any other type of tubular structure that is used to transmit fluid, power or communications into or out of a wellbore.

[0016] The enlarged bore portion **27** of the central mandrel **12** accommodates an actuating sleeve **62** and an internal guide sleeve **64**. The guide sleeve **64** provides a radially exterior surface **66** that defines the inner boundary of the lateral cable opening **38**. Additionally, the guide sleeve **64** presents an inner surface **68** with an upper radially is enlarged bore portion **70**. The actuating sleeve **62** presents an inner surface **72** that extends radially inwardly of the enlarged bore **70**, thereby creating an engagement shoulder **74** at the lower end of the sleeve **62**. The outer radial surface **76** of the actuating sleeve **62** carries a number of annular fluid seals **78**, a dog recess **80** and a locking ring **79**. It is noted that the actuating sleeve **62** is axially moveable between a lower position, shown in FIG. **1**, wherein the lower end of the sleeve **62** contacts the guide sleeve **64**, and an upper position, shown in FIG. **2**, wherein the upper end **82** of the actuating sleeve **62** contacts an internal stop shoulder **84** of the central mandrel **12**. Frangible shear screws **82** pass through the body of the central mandrel **12** and into the actuating sleeve **62** to initially secure the actuating sleeve **62** in its lower position.

[0017] A plurality of radial fluid communication ports **88** also pass through the central mandrel **12** to provide fluid communication between the internal flowbore **16** of the mandrel **12** and its radial exterior. As FIG. **2** illustrates, the shear screws **82** are angularly offset from each of the fluid ports **88** about the circumference of the central mandrel **12**. Fluid flow through the fluid ports **88** is initially blocked by the presence of the actuating sleeve **62** and fluid seals **78**.

[0018] Beginning once again proximate the upper end of the packer assembly **10**, a second set of longitudinal anti-rotation splines **90** are defined upon the central mandrel body **12**. Splines **90** interfit with complimentary anti-rotation splines **92** on the central mandrel **12**. The interfitting of the splines **90**, **92** prevents rotation of the central mandrel **12** components with respect to one another.

[0019] The ring **98** is retained in place upon the outer surface of the central mandrel **12** by a housing sub **100** that is secured to the central mandrel **12** by threaded connection **22**. An annular space **102** is defined between the lower end of the housing sub **100** and the outer surface of the central mandrel **12**. Ring **104** is secured to the lower end of the housing sub **100** at threaded connection **106**. The ring **104** provides tensioning portions **105**, of a type known in the art, for exerting a tensioning force upon the packer element **110**.

[0020] An upper end setting sleeve **108** also surrounds the central mandrel **12** below the ring **104**. The setting sleeve **108** is used to help set the packer element **110** that lies immediately below it on the radial exterior of the central mandrel **12**. During setting of the packer assembly **10**, the upper end setting sleeve **108** remains stationary with respect to the central mandrel **12**. The upper end setting sleeve **108** has a retainer portion **112** that extends over a portion of the packer element **110**. A lower end setting sleeve **114** is located at the lower end of the packer element **110** and also presents a retainer portion **116** that extends over a portion of the packer element **110**.

[0021] The packer element **110** is preferably a composite packer element as described in U.S. Pat. No. 6,843,315, issued to Coronado et al. This patent is owned by the assignee of the present invention and is herein incorporated by reference. This type of packer element is suitable for use in creating a fluid seal in larger bores and even uncased borehole sections. Below the lower end setting sleeve **114** is a setting, or actuating, assembly, generally shown at **118**, having an upper sub **120** with fluid fill port **122**, a setting assembly housing **124** and a lower sub **126**. The setting assembly housing **124** encases an atmospheric chamber **128**. The atmospheric chamber **128** is bounded at axial ends by the upper and lower subs **120**, **126**. When the piston assembly **10** is in the unset position (shown in FIG. **1**), the atmospheric chamber **128** is at atmospheric pressure.

[0022] An actuating piston, generally shown at **130**, is retained within the atmospheric chamber **128**. The actuating piston **130** is made up of a lower piston ring **132**, central ring **134**, and an upper piston ring **136**, these components being affixed to one another by threaded connections **138**, **140**. The lower piston ring **132** presents a fluid pressure receiving area **142**. Additionally, the lower piston ring **132** has an annular dog recess **144** inscribed upon its inner surface. Elastomeric O-ring seals **146** are used to provide fluid sealing between the actuating piston **130** and the chamber **128**. The upper end of the upper piston ring **136** is secured by threaded connection **148** to a body lock ring assembly **150**. The body lock ring assembly **150** includes a locking ring **152** with an inner ratchet surface **154**. The ratchet surface **154** is formed to interengage with outwardly-facing ratchet surface **156** on central mandrel **12**. Packer element setting member **158** is affixed to the body lock ring assembly **150** and presents an enlarged setting portion **160** that abuts the lower end of the packer element **110**.

[0023] A locking dog **162** initially secures the actuating piston **130** and the central mandrel **12** together. In the unset position, shown in FIG. **1**, the dog **162** resides within a dog passage **164** that is disposed radially through the central mandrel **12**. A portion of the dog **162** extends outwardly into dog recess **144** in the actuating piston **130**. Movement of the dog **162** radially inwardly is blocked by the presence of actuating sleeve **62**. It is noted that the dog **162** and all shear screws **82** are radially offset from the cable feed-through path(s) **18** so that the feed-through path(s) **18** remain unexposed to fluid ingress and wellbore pressures. This arrangement is best shown in FIGS. **2** and **3**.

[0024] Hydrostatic forces are used to set the packer device **10**. FIGS. **4A-4C** show the packer device **10** in a set condition. When it is desired to set the packer assembly **10**, a shifting tool (not shown), of a type known in the art, is disposed into the flowbore **16** of the central mandrel **12**. The shifting tool contacts the engagement shoulder **74** of the actuating sleeve **62** and moves the actuating sleeve **62** axially upwardly. This movement will shear the shear screws **82** and unblock fluid communication ports **88**. The locking ring **79** secures into a mating recess in the central mandrel **12** (see FIG. **4C**) to secure the actuating sleeve **62** in the upward position. Additionally, upward movement of the actuating sleeve **62** will bring the dog recess **80** into general alignment with the locking dog **162**. The dog **162** is moved radially inwardly to reside partially within the recess **80** and is thus moved out of the outer dog recess **144**. This unlocks the actuating piston **130** from engagement with the central mandrel **12**. As upward movement of the actuating sleeve **62** unblocks the fluid ports **88**, hydrostatic fluid pressure present within the flowbore **16** will then be transmitted through the ports **88** and enter the pressure receiving area **142**. Wellbore hydrostatic pressure will bear upon the pressure receiving area **142** of the actuation piston **130** and urge the piston **130** axially upwardly. The packer element setting member **158** will compress the packer element **110** axially to cause it to expand radially and become set.

[0025] It can be seen that the arrangement of the present invention provides a means for disposing one or more cables axially through a hydrostatically-set packer device while also permitting radial fluid communication through the central mandrel. The feed-through paths **18** of the packer assembly **10** desirably isolate the cables from fluid pressure present in either the flowbore **16** or the annulus surrounding the packer device **10**. Because the feed-through paths **18** are angularly offset from the fluid communication ports **88** about the circumference of the central mandrel **12**, fluid pressure being communicated radially through the mandrel **12** will not enter the feed-through paths **18**.

[0026] Cables extending through the feed-through paths **18** are also protected from axial tensional forces that would be exerted upon the packer assembly **10** as it is being used as well as torsional forces that might be experienced as the packer assembly **10** is being made up or run in the well. The cables are retained in place within the feed-through path(s) **18** by end nuts **48**, **56**, which secure them to the central mandrel **12**.

[0027] Those of skill in the art will recognize that numerous modifications and changes may be made to the exemplary designs and embodiments described herein and that the invention is limited only by the claims that follow and any equivalents thereof.

What is claimed is:

1. A packer assembly for creating a fluid seal within a wellbore comprising:

a tubular central mandrel having an upper end and a lower end, defining a central flowbore and having an outer radial surface;

a packer element surrounding the tubular mandrel, the packer element being moveable between a radially reduced unset position and a radially expanded set position;

a hydrostatic setting assembly for selectively causing the packer element to be set in its expanded position, the hydrostatic setting assembly comprising:

a) a radial fluid communication port for communicating hydraulic fluid pressure within the central flowbore through the tubular mandrel to its outer radial surface;

b) a piston element for receiving fluid pressure from the central flowbore and applying said fluid pressure to urge the packer element toward its set position; and

a cable feed-through path defined within the tubular mandrel to allow a cable to pass from the upper end of the mandrel to the lower end of the mandrel.

2. The packer assembly of claim 1 wherein the cable feed-through path comprises a longitudinal drilled hole in the mandrel.

3. The packer assembly of claim 1 wherein the setting piston is releasably secured to the central mandrel by a locking dog.

4. The packer assembly of claim 1 wherein the fluid communication port is angularly offset from the feed-through path about the circumference of the central mandrel.

5. The packer assembly of claim 1 wherein the setting assembly further comprises an actuating sleeve that lies within the central flowbore and is moveable between a first position, wherein fluid communication through the radial fluid communication port is blocked, and a second position, wherein the actuating sleeve does not block the port.

6. The packer assembly of claim 5 wherein the actuating sleeve presents an engagement shoulder that is shaped and sized to be contacted by a suitable shifting tool for movement of the actuating sleeve from its first to its second position.

7. The packer assembly of claim 5 wherein:

the setting piston is releasably secured to the central mandrel by a locking dog; and

wherein movement of the actuating sleeve from the first to the second position releases the setting piston from the central mandrel.

8. The packer assembly of claim 1 wherein the packer element comprises a composite packer element for use in creating a fluid seal within an uncased borehole.

9. A system for disposing a cable axially through a packer device that is set hydrostatically, the system comprising:

a central tubular mandrel defining a flowbore to contain hydrostatic pressure;

a packer element carried by the central mandrel, the packer element being moveable between an unset position and an axially compressed set position;

a setting mechanism for moving the packer element to its set position in response to hydrostatic pressure within the flowbore; and

a feed-through path defined axially through the mandrel, the feed-through path retaining a cable in isolation from external fluid pressures.

10. The system of claim 9 further comprising:

a radial fluid communication port for transmitting hydrostatic fluid pressure from the flowbore to an actuation chamber located radially outside of the central mandrel; and

wherein the fluid communication port is angularly offset from the feed-through path about the circumference of the central mandrel.

11. The system of claim 9 wherein the feed-through path comprises a longitudinal drilled hole in the central mandrel.

12. The system of claim 10 wherein the setting mechanism further comprises a piston element retained within the actuation chamber for receiving fluid pressure from the central flowbore and applying said fluid pressure to urge the packer element toward its set position.

13. The system of claim 12 wherein the piston element is releasably secured to the central mandrel.

14. The system of claim 13 wherein the piston element is releasably secured to the central mandrel by a locking dog.

15. The system of claim 9 wherein the setting mechanism further comprises an actuating sleeve that lies within the flowbore and is moveable between a first position, wherein fluid communication through the radial fluid communication port is blocked, and a second position, wherein the actuating sleeve does not block the port.

16. The system of claim 15 wherein the actuating sleeve is releasably retained in the first position by a shear pin.

17. A method of disposing a cable axially through a hydrostatically-set packer device, the method comprising the steps of:

forming a cable pass-through path within a central mandrel of the packer device;

disposing a cable along the cable pass-through path; and

securing an end nut upon the cable to secure the cable to the central mandrel.

18. The method of claim 17 wherein the step of forming a pass-through path within the central mandrel comprises drilling a longitudinal hole within the central mandrel that is shaped and sized to accommodate the cable.

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