Dec. 13, 1966 J. D. MOTT 3,291,220

HYDRAULIC SET LINER HANGER

Filed April 17, 1964 2 Sheets-Sheet 1

Fig. 1

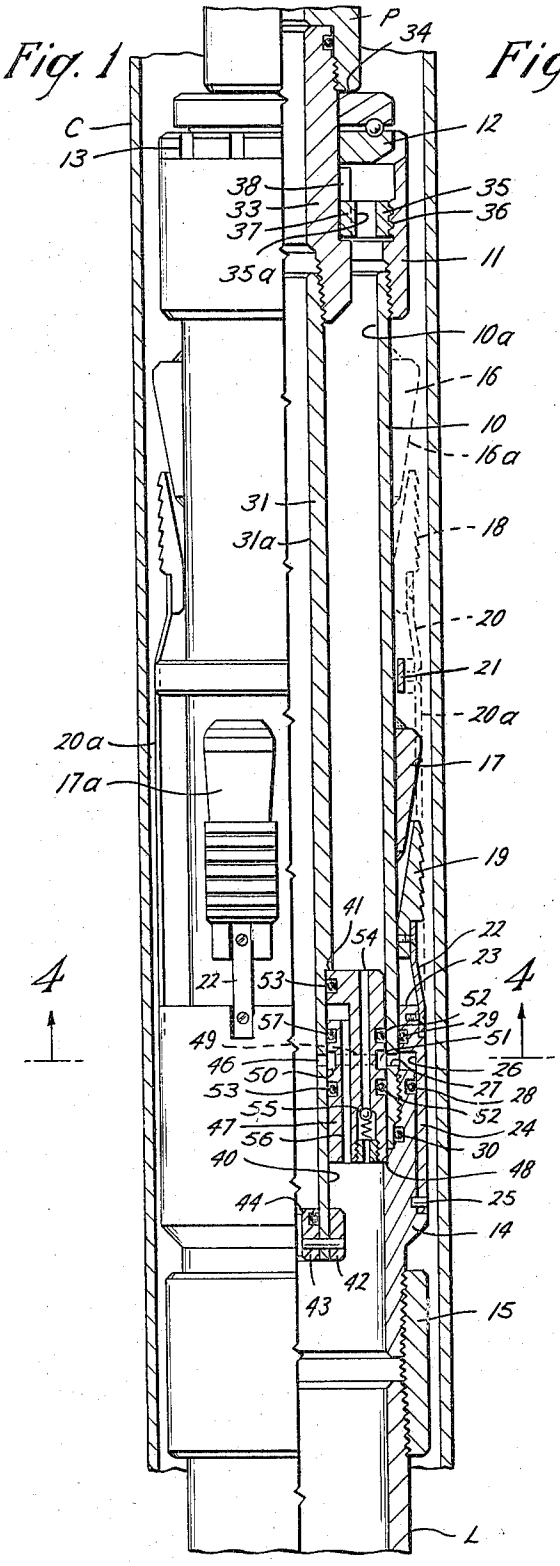
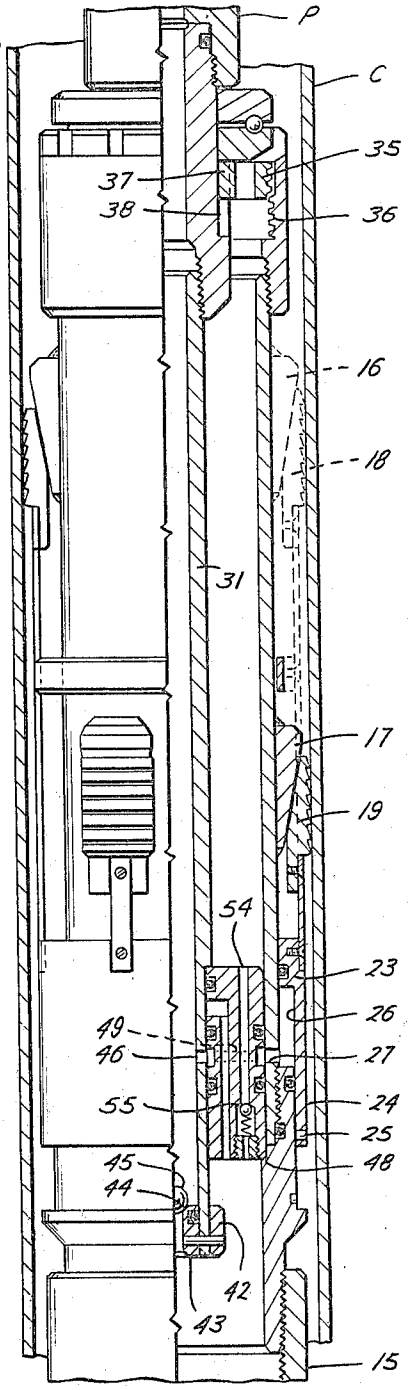


Fig. 2



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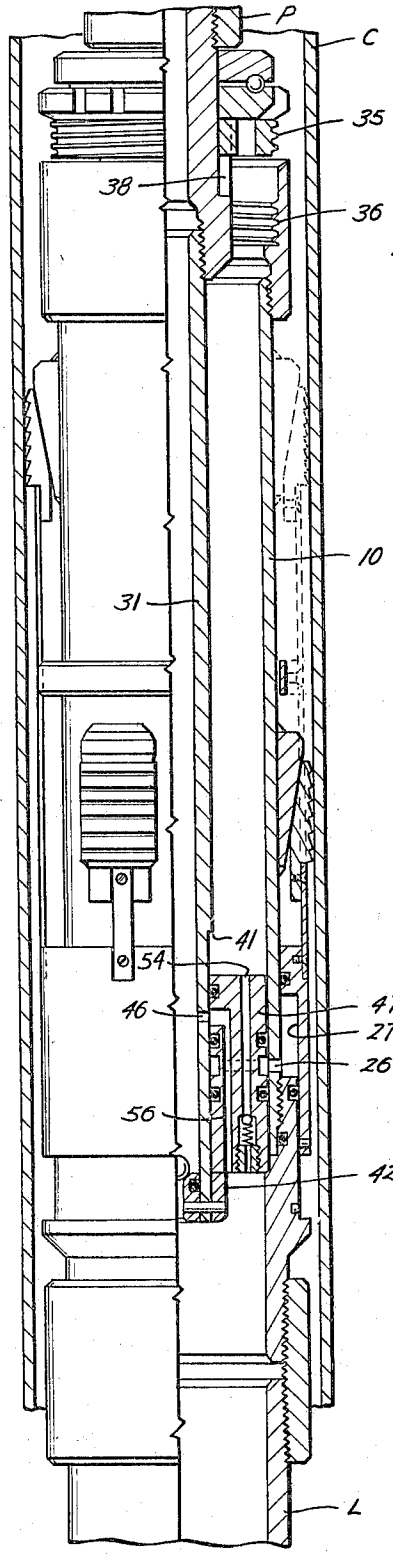

Fig. 3

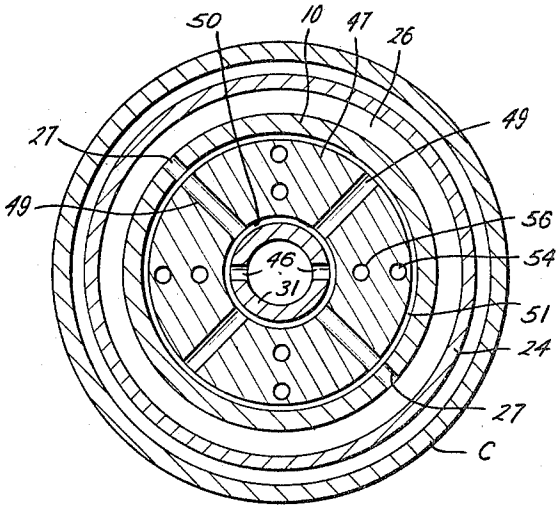

Fig. 4

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HYDRAULIC SET LINER HANGER

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6 Claims. (Cl. 166—208)

This invention relates to a liner hanger apparatus and more particularly to improvements in a hydraulically-operated liner hanger adapted to be set in a well casing.

The primary object of this invention is to provide a liner hanger employing means by which pressure fluid for setting the hanger is supplied from the setting tool, the means being so constructed and arranged that it may be readily removed from the hanger body when the setting tool is withdrawn, without requiring the drilling-out or other more difficult operations to clear the bore of the hanger body, as is frequently the case with more conventional designs.

An important object is the provision of a fluid transfer and sealing sleeve carried on the setting tool and slidable inside the hanger body, the sleeve being provided with transverse passages for communicating pressure fluid from the setting tool to the hydraulically operated hanger setting devices.

Another object is the provision of such a sleeve means having, in addition to the transverse passages for communicating pressure fluid from the setting tool to the hydraulically operated apparatus, longitudinally extending passages for controlling the fill-up of the running-in string with fluid as it is being run, and to also discharge fluid from the setting tool and operating string as the latter are pulled from the well after the hanger has been set, to thereby avoid carrying fluid to the surface.

Other and more specific objects of this invention will become more readily apparent from the following detailed description when read in conjunction with the accompanying drawing which illustrates a useful embodiment in accordance with this invention.

In the drawing:

FIG. 1 is a longitudinal, quarter-sectional view showing the hanger liner inserted in a well casing with the hanger parts in the running-in or non-actuated positions;

FIG. 2 is a view similar to FIG. 1 showing the parts in the positions occupied when the hanger is set;

FIG. 3 is a view similar to FIGS. 1 and 2 showing the position of the setting tool during a stage of its release from the liner hanger; and

FIG. 4 is a cross-sectional view taken generally along line 4—4 of FIG. 1.

Referring to the drawing, the liner hanger apparatus in accordance with this invention, is shown in a well casing C which, it will be understood, lines a well bore, and to which a liner L is to be attached by means of the liner hanger apparatus. The liner hanger apparatus comprises a generally tubular body 10 having a bore 10*a*. The upper end of body 10 is screwed into a coupling sleeve 11, the upper end of which forms a seat for a conventional anti-friction bearing 12 which is provided with a plurality of radial slots 13 affording fluid communication between the exterior of the hanger body and the bore thereof. The lower end of body 10 is screwed into the upper end of a tubular sub 14, the lower end of which is threaded for connection to liner L by means of a threaded collar 15. Mounted below sleeve 11 on the exterior of body 10 in longitudinally spaced relation are upper and lower slip expanders 16 and 17, respectively, each of the expanders being of conventional form having angularly spaced slots defining inwardly sloping surfaces 16*a* and 17*a*, respectively, to co-operably engage upper and lower sets of toothed pipe-gripping wedges or slips 18 and 19, respectively, for urging the slips radially outwardly into gripping engagement with wall C in response to relative longitudinal movement between the expanders and the related slips. The slips of one set are angularly staggered with respect to the slips of the other set.

The slips of upper set 18 are carried on the upper ends of resilient arms 20 which are mounted on a cage ring 21 slidably disposed about the exterior of body 10. The slips of lower set 19 are similarly mounted on resilient arms 22 which are, in turn, secured to an annular cylinder head 23 slidably disposed about the exterior of body 10 adjacent its lower end and above sub 14. Arms 20 of the upper slips have downward extensions 20*a* which are secured at their lower ends to cylinder head 23, and thereby normally support the upper set of slips from cylinder head 23, as well as from cage ring 21. While two sets of slips are shown, it will be understood that in many instances only one set of slips will be required. The number of slips and the general arrangement and details thereof are generally conventional and are intended to be illustrative of various radially expansible and contractible devices commonly employed in well tools such as liner hangers, packers, and the like.

Cylinder head 23 is provided with a cylindrical skirt 24 which extends downwardly about the exterior of sub 14 in a close slidable relation and is initially secured to the sub in its lowermost postion by means of shear pins 25. Cylinder head 23, skirt 24 and the upper end of sub 14 co-operate with the exterior of body 10 to define an expansible pressure chamber 26. Radial inlet ports 27 are provided through the wall of body 10 to communicate pressure chamber 26 with the bore of body 10. Seal packing 28 is arranged between the exterior of sub 14 and cylinder skirt 24 below chamber 26 and seal packings 29 and 30 are provided between the inner wall of sub 14 and the exterior of body 10 above and below ports 27 to provide the requisite sealing for pressure chamber 26. Arms 20 and 22 are constructed to normally bias the slips inwardly toward the hanger body so that they are normally retracted to be out of engagement with the wall of casing C when the apparatus is being run into the well.

Extending into the bore of body 10 is a tubular setting tool or mandrel 31 having a bore 31*a*. The upper end of setting tool 31 is screwed into a tubular coupling member 33, the upper end of which is adapted to be received in a collar P attached to the lower end of a section of an operating pipe string (not shown). Coupling member 33 extends through the bore of bearing 12 which is held in place between the upper end of bearing sleeve 11 and the shoulder 34 formed by the lower end of collar P, the bearing furnishing anti-friction means aiding free rotational movement of the setting tool relative to the hanger body.

A conventional releasable connection is provided between the setting tool and the hanger body. This connection includes an annular travelling nut 35, having longitudinal passages 35*a* therethrough, which forms a releasable connection between coupling 33 and connector sleeve 11. The latter is provided with a short section of coarse threads 36 which mate with corresponding threads on the exterior of nut 35. The bore of nut 35 is provided with a plurality of longitudinal splines 37 which ride in cooperating spline grooves 38 formed on the exterior of coupling member 33. The bore wall of connector sleeve 11 has an unthreaded portion above threads 36 to receive travelling nut 35 when the latter is moved out of engagement with threads 36 after a suitable number of rotations of the setting sleeve.

The lower end of setting tool 31 is provided with reduced diameter portion 40 defining at its upper end an external downwardly facing shoulder 41. An abutment ring 42 is secured to the exterior of the lower end of

reduced diameter portion **40** and a seat ring **43** is mounted in the lower end of bore **31***a* of the setting tool and is provided about its upper edge with a tapered seat **44** adapted for reception of a closure member, such as a ball **45** (FIG. 2). One or more radial discharge ports **46** are provided through the wall of portion **40** of the setting tool.

Slidably disposed about portion **40** of the setting tool is a sealing sleeve **47** which is somewhat shorter in length than the distance between shoulder **41** and the upper end of abutment ring **42**, thereby providing a limited degree of relative longitudinal movement between sleeve **47** and the setting tool. Sleeve **47** has a thickness such as to span the annular space between the setting tool and the bore wall of hanger body **10** and extend into a slidable engagement with the latter. The hanger body has an internal upwardly facing shoulder **48** to limit downward movement of sleeve **47**, so that when the setting tool is fully inserted in hanger body **10** in the running-in position, as seen in FIG. 1, sleeve **47** will be held in place between shoulders **41** and **48**.

Sleeve **47** is provided with one or more transverse passages **49** which communicate at their opposite ends with annular grooves **50** and **51** provided in the interior and exterior walls, respectively, of sleeve **47**. Grooves **50** and **51** and the connecting passages **49** are positioned in sleeve **47** to be in registration with ports **27** and **46** when the sleeve is seated on shoulder **48** and held down thereon by engagement of shoulder **41** with the upper end of the sleeve.

Passages **49** serve to provide fluid communication between bore **31***a* of the setting tool and pressure chamber **26**. Suitable seal packings **52—52** are provided between the exterior of sleeve **47** and the bore wall of hanger body **10** above and below groove **51**, and similar seal packings **53—53** are provided between the interior wall of sleeve **47** and the exterior of portion **40** of the setting tool on opposite sides of grooves **50** to prevent leakage of fluid between sleeve **47** and the setting tool hanger body. Sleeve **47** is provided with a passage **54** extending longitudinally through the body of the sleeve from end to end thereof. A downwardly opening check valve **55** is mounted in the lower end portion of passage **54** to allow downward passage of fluid through the annular space between the setting tool and the packer body.

Sleeve **47** may be provided with a second longitudinal passage **56** which extends from the lower end of the sleeve to a point between upper seal packing **53** and transverse passage **49** where the upper end of passage **56** opens through the inner wall of the sleeve. A seal packing **57** is positioned between the inner wall of sleeve **47** and portion **40** of the setting tool at a point between the upper end of passage **56** and transverse passage **49**. Longitudinal passage **56** serves as a fluid "dump" passage in the operation of the tool, as will be described hereinafter.

Operation of the tool is conducted substantially in the following manner: The tool, assembled as shown in FIG. 1, is run into casing C to the point at which the liner hanger is to be set. During this operation the liner may be filled with fluid, as is commonly done, in order to prevent collapse, as entry of fluid into the liner from below will normally be prevented by the back-pressure valve ordinarily provided in the cementing shoe carried by the lower end of the liner. The fluid to fill the running-in-string will flow through slots **13** in the connector sleeve and passages **35***a* in the travelling nut into the annular space between the setting sleeve and the hanger body, and thence through passages **54** and check valves **55** into the interior of liner L and thence through the bore of the setting tool and into the running-in-string.

When the liner hanger is in place, closure ball **45** will be pumped, along with water, mud or other pressure fluid, through the operating string into the bore of setting tool **31** and will come to rest on seat **44** of seat ring **43**, thereby closing-off the bore of the setting tool below ports **46**.

Thereupon, increased pressure on the hydraulic fluid in the bore of the operating string will be transmitted through discharge ports **46**, transverse passages **49**, and inlet ports **27** into pressure chamber **26**. When the pressure is increased sufficiently, shear pins **25** will be broken, allowing cylinder head **23** to be forced upwardly thereby urging slips **19** and **18** over their respective expander elements **17** and **16**. The slips will be forced outwardly to anchor the hanger to the wall of casing C, as best seen in FIG. 2.

When the liner hanger has thus been effectively anchored to casing C, the operating string will be rotated a sufficient number of turns to cause travelling nut **35** to move upwardly on threads **36** until the connection between the setting tool and the hanger body is released, also as seen in FIG. 2, freeing the setting tool for removal from the hanger body. Thereupon, an upwardly pull will be applied to the operating string attached to the setting tool and the latter will be drawn upwardly. The initial upward movement will bring the upper end of abutment ring **42** into engagement with the lower end of sleeve **47**, as best seen in FIG. 3. This relative movement between the setting tool and sleeve **47** will move ports **46** into registration with the upper end of dump passage **56**. This communication will allow the load of liquid in the bore of the operating string and the setting tool to be discharged through passage **56** into the bore of liner L and allow the operating string to be pulled upwardly without carrying a load of liquid with it. Any liquid remaining in the annular space between the setting tool and the hanger body above sleeve **47** will likewise be dumped through passage **54**. Continued upward movement of the operating string will then pull sleeve **47** out of the bore of hanger body **10** and leave the latter fully open throughout its length ready to receive any other well pipes or tools as may be required for subsequent equipping and operation of the well.

It will be evident that various changes and modifications may be made in the details of the illustrative embodiment within the scope of the appended claims but without departing from the spirit of this invention.

What I claim and desire to secure by Letters Patent is:

1. In a liner hanger apparatus adapted to be set in a well casing disposed in a well bore, a tubular body, normally retracted means on said body adapted to be expanded outwardly against the well casing, hydraulically operable means on said body for expanding said normally retracted means, inlet port means through the wall of said body for providing fluid communication to said hydraulically operable means, a tubular setting tool extending into the bore of said body, means releasably connecting said setting tool to said body, discharge port means through the wall of said setting tool for providing fluid communication between the interior and the exterior thereof, and a sleeve member carried on the exterior of said setting tool for limited relative longitudinal movement thereon and extending into slidable sealing engagement with said body, said sleeve member having transverse passages movable into and out of communication between said discharge and inlet port means by longitudinal movement of the setting tool relative to said body.

2. In a liner hanger apparatus adapted to be set in a well casing disposed in a well bore, a tubular body, normally retracted means on said body adapted to be expanded outwardly against the well casing, hydraulically operable means on said body for expanding said normally retracted means, said hydraulically operable means including hollow piston means slidably mounted on said body, inlet port means through the wall of said body communicating the bore thereof with the interior of said piston means, a tubular setting tool extending into the bore of said body, means releasably connecting said setting tool to said body, discharge port means through the wall of said setting tool providing fluid communication between the interior and the exterior thereof, a sealing

sleeve member carried on the exterior of said setting tool and extending into slidable sealing engagement with said body, said sleeve member having transverse passages movable into and out of communication between said discharge and inlet port means by longitudinal movement of the setting tool relative to said body, and a passageway extending longitudinally entirely through said sleeve member, and downwardly opening check valve means controlling said passageway.

3. In a liner hanger apparatus adapted to be set in a well casing disposed in a well bore, a tubular body, normally retracted means on said body adapted to be expanded outwardly against the well casing, hydraulically operable means on said body for expanding said normally retracted means, said hydraulically operable means including hollow piston means slidably mounted on said body, inlet port means through the wall of said body communicating the bore thereof with the interior of said piston means, a tubular setting tool extending into the bore of said body, means releasably connecting said setting tool to said body, discharge port means through the wall of said setting tool providing fluid communication between the interior and the exterior thereof, a sealing sleeve member carried on the exterior of said setting tool for limited relative longitudinal movement and extending into slidable sealing engagement with said body, said sleeve member having transverse passages movable into and out of communication between said discharge and inlet port means by longitudinal movement of the setting tool relative to said body, a first passageway extending longitudinally entirely through said sleeve member, downwardly opening check valve means controlling said first passageway, and a second passageway having one end communicating with the lower end of said sleeve member and its upper end positioned to communicate with said discharge port means in response to said limited relative longitudinal movement between said setting tool and said sleeve member.

4. In a liner hanger apparatus adapted to be set in a well casing disposed in a well bore, a tubular body, normally retracted means on said body adapted to be expanded outwardly against the well casing, hydraulically operable means on said body for expanding said normally retracted means, inlet port means through the wall of said body for providing fluid communication to said hydraulically operable means, a tubular setting tool extending into the bore of said body, means releasably connecting said setting tool to said body, discharge port means through the wall of said setting tool for providing fluid communication between the interior and the exterior thereof, and a sleeve member carried on the exterior of said setting tool and extending into slidable sealing engagement with said body, said sleeve member having transverse passages movable into and out of communication between said discharge and inlet port means by longitudinal movement of the setting tool relative to said body, and opposed shoulder means on said setting tool and said body engageable with the opposite ends of said sleeve member to hold said sleeve member in the position establishing communication between said discharge and inlet port means when said setting tool is connected to said body.

5. A liner hanger, comprising a tubular body connectible into a liner string, a tubular slip cage slidably mounted on the mandrel, means releasably securing the slip cage to the body, two vertically spaced sets of circumferentially spaced pipe-gripping slips mounted in fixed longitudinal relation on the cage about the body, downwardly tapering slip expander members mounted on the body in positions to expand both sets of slips in response to relative longitudinal movement of the slips and expander members toward each other, fluid pressure-actuated means mounted on the body for moving the slip cage longitudinally of the body whereby to move said slips toward said expander members, and means for directing pressure fluid from the interior of said body to said fluid pressure-actuated means.

6. A liner hanger according to claim 5 wherein the slips of one set are angularly staggered with respect to the slips of the other set.

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