July 20, 1965 C. C. BROWN 3,195,646

MULTIPLE CONE LINER HANGER

Filed June 3, 1963

Fig. 1

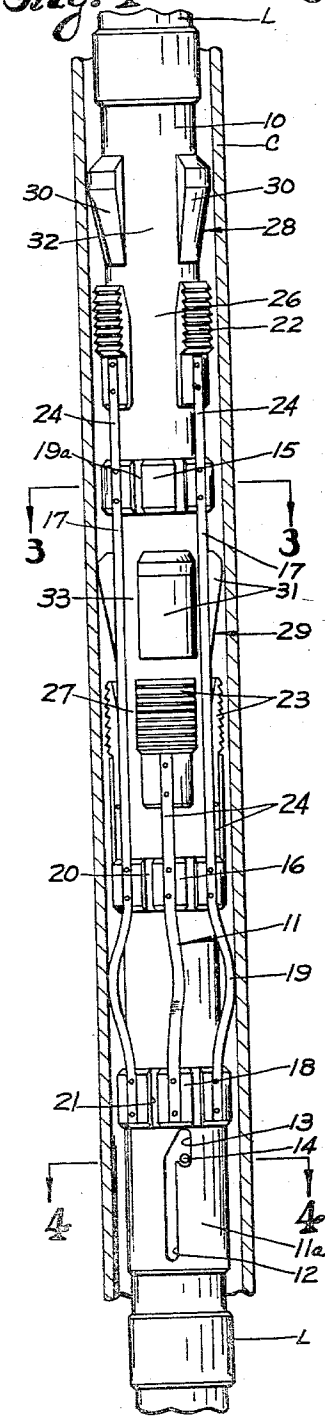


Fig. 2

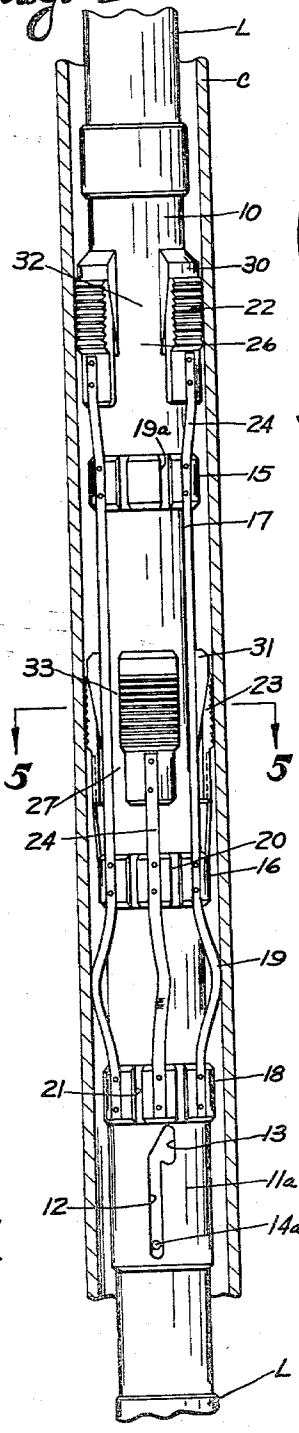


Fig. 3

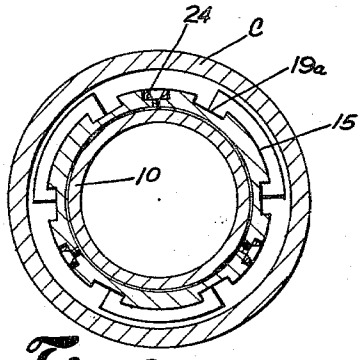


Fig. 4

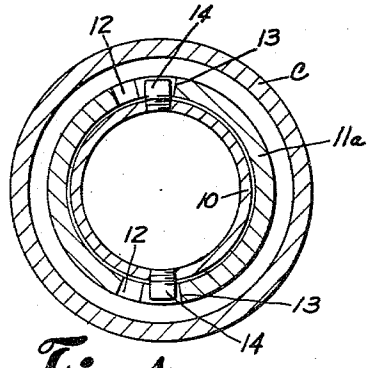
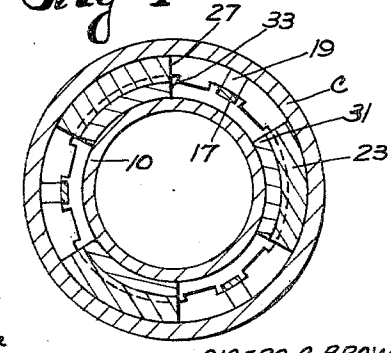


Fig. 5



CICERO C. BROWN
INVENTOR.

BY

ATTORNEY

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MULTIPLE CONE LINER HANGER

Cicero C. Brown, % Brown Oil Tools, Inc., P.O. Box 19236, Houston, Tex.

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This invention relates to liner hangers for use in equipping wells.

Liner hangers are usually employed to attach an inner string of well pipe or casing to the lower end or at some other point within a larger diameter well pipe or casing. Liner hangers ordinarily comprise an apparatus attachable to the liner and which includes a set of pipe-gripping slips which are arranged to be expanded into gripping engagement with the interior of the larger diameter pipe to thereby secure the smaller diameter pipe or liner thereto. Thereafter, the liner will usually be cemented, which requires, of course, the circulation of fluids through the interior of the liner and upwardly about the exterior thereof between the liner and the outer casing.

Frequently, the liners comprise long and heavy strings of pipe extending below the hanger and therefore require large slip contact areas in order to assure effective attachment of the liner within the pre-existing casing. However, because of the close clearances which must frequently exist between the liner and the surrounding well casing, or open hole in some cases, if sufficient slip area is provided to support such a long and heavy liner string, this will frequently tend to close off the annular space between the liner and the surrounding well wall and thereby severely restrict the flow of fluid, which it is necessary to circulate both in connection with the cementing of the liner and to prevent its sticking in the well bore when it is being run.

Accordingly, it is a primary object of the present invention to provide an improved liner hanger designed to overcome the difficulties, such as those outlined above, which are experienced with more conventional hangers.

An important object is the provision of a liner hanger which, while having adequate contact area to support long and heavy liner strings, will also have fluid passage areas sufficient to assure free fluid circulation while the liner is being run.

It is a further important object of this invention to provide a liner hanger of the character described which is of relatively short and compact construction to facilitate running in the well and which requires very little manipulation of the liner string in order to actuate and release the hanger.

Other and more specific objects and advantages 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 an elevational view showing a liner hanger in accordance with this invention in the unset position as it is run into a well bore;

FIG. 2 is a view similar to FIG. 1, showing the liner in set position;

FIG. 3 is a cross-sectional view taken along line 3—3 of FIG. 1;

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

FIG. 5 is a cross-sectional view taken along line 5—5 of FIG. 2.

Referring to the drawing:

The liner hanger includes the tubular mandrel 10 which is connectible into the liner pipe string L, which is to be run into the well. Mandrel 10 is generally of

substantially the same diameter as the pipe comprising the liner string. The liner hanger is shown inserted in the bore of a pre-installed well casing C to which the liner is to be attached. Slidably mounted about the mandrel, near its lower end, is a slip cage, designated generally by the numeral 11, and including a tubular sleeve 11*a* which is releasably secured to the mandrel by means of a conventional J-slot-and-pin connection. In the embodiment illustrated, the J-slot is inverted and includes the long leg 12, the short leg or Jay 13 which cooperate with a pin 14 projecting radially from mandrel 10. Ordinarily, two of these J-slot-and-pin connections are employed on diametrically opposite sides of the tool. Supported on the upper end of sleeve 11*a* are vertically spaced upper and lower slip support collars 15 and 16, respectively, which are connected to each other by a plurality of circumferentially spaced narrow elongate metal links 17.

Lower slip support collar 16 is connected to a mounting collar 18 on sleeve 11*a* by means of a plurality of circumferentially spaced bow or drag springs 19 which are adapted in the well-known manner to frictionally engage the wall of casing C in order to resist the longitudinal and rotative movement of the slip cage relative to the mandrel in the course of operation of the device, as will appear subsequently. Each of the several collars 15, 16 and 18 are provided with circumferentially spaced longitudinal slots 19*a*, 20, and 21, respectively, to provide flow passages for circulation of fluid between these collars and the surrounding casing C.

A set of pipe-gripping slips is supported in elevated relation from each of the slip support collars, the upper set of slips being designated by the numeral 22 and the lower set of slips being designated by the numeral 23. Each of the slips is secured to its respective slip collar by means of a spring arm 24 which normally bias the slips inwardly toward the wall of mandrel 10. Upper arms 24 may be extensions of links 17, and lower arms 24 may be extensions of drag springs 19. The lower set of slips 23 is spaced substantially below upper slip support collar 15. The slips are generally rectangular in shape and comparatively narrow in width, providing substantial spaces 26 and 27, respectively, between slips 22 and 23. In the illustrative embodiments there are three slips in each set spaced on centers 120° apart and the relative widths of the slips and spaces are approximately the same, so that about half of the circumference of the annulus occupied by each set of slips is in the form of open passageways between the slips.

Mounted above the respective sets of slips are upper and lower downwardly tapering slip expander cones, designated generally by the numerals 28 and 29, respectively. Each of the slip expander cones is defined by a plurality of circumferentially spaced cone segments, designated respectively by the numerals 30 and 31, which are spaced apart to provide the channels or spaces 32 and 33, respectively, between the segments of the respective cones. In the illustrative embodiments, each of the slip cones is defined by three segments spaced apart 120° on centers. The widths of the respective cone segments are approximately the same as the widths of the related slips, hence, the spaces 32 and 33 will likewise correspond to about half the total circumference of the cones.

Each of the cone segments is vertically aligned with the related slips and in the preferred arrangement, the slips and cone segments of one of the sets will be angularly oriented with respect to the other set, so that the slips and cone segments of one set will be effectively staggered or interspersed with the slips and cone segments of the other sets. It will be evident that when the liner hanger is manipulated to produce relative longitudinal movement between the mandrel and the slips, the cone

segments will be caused to move inside the slips so that the tapered surfaces of the cone segments will cooperate with the corresponding surfaces on the interior faces of the related slips to urge the latter radially outwardly into gripping engagement with the wall of casing C.

In operation, the liner hanger will be installed in liner string L and J-pins **14** will be locked into the short legs **13** of the J-slots. As the device is pushed downwardly through casing C, the pins engaging the bottoms of short legs **13** will push the slip cage downwardly overcoming the friction of drag springs **19** and thereby holding the sets of slips out of engagement with the respective cone segments. When the setting point is reached in casing C, a slight upward pull on the liner string and slight rotation to the right will move pins **14** into the longer legs **12** of the J-slots, thereby releasing the hanger mandrel for longitudinal movement relative to the slip cage. The liner string will then be lowered, moving the cone segments **30** and **31** into expansive engagement with the related slips, the drag springs **19** serving to hold the slip cage and slips stationary while this relative movement of the liner and mandrel occurs. When the weight of the liner string is thus placed on the slips, the latter will thereby be forced into strong anchoring engagement with the wall of casing C, as shown particularly in FIG. 2.

By providing the two sets of staggered or interspersed slips a substantially continuous ring of slip contact surface is effectively formed for engagement with substantially the entire circumference of casing C, thereby assuring sufficiently strong anchorage of the liner string to the casing to support heavy liner strings. At the same time, the several passages **19***a*, **20** and **21** in the slip support collars, and spaces **26**, **27**, **32** and **33** between the slips and the slip cone segments will provide substantial areas for the circulation of fluid through the well bore between the hanger and the outer casing.

To release the hanger, it is only necessary to pick up on the liner string sufficiently to bring pins **14** into a position opposite the short legs **13** of the J-slots. This will raise the cone segments out of engagement with their related slips and release the latter for backward movement under the biasing force of the arms **24** which will thereby pull the slips away from the casing. The upward movement of the liner will, through engagement of pins **14** with the sloping sides of the upper ends of the J-slots, automatically bring the pins in engagement with the upper ends of short legs **13**, whereupon, the entire structure can be pulled upwardly out of the well bore.

It will be understood that various other alterations and modifications may be made in the details of the illustrative embodiments 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. A liner hanger, comprising, a tubular mandrel connectible into a liner string, a tubular slip cage slidably mounted on the mandrel, J-slot-and-pin-type connection means releasably securing the cage to the mandrel, means carried by the slip cage operable to frictionally engage a surrounding well pipe, said slip cage including two vertically spaced slip-support collars fixedly connected to each other slidably surrounding said mandrel, a set of circumferentially spaced pipe gripping slips mounted about the mandrel above each of said collars, spring arms supporting said slips from the respective collars and biasing the slips inwardly toward the mandrel, a downwardly tapering slip expander cone mounted on the mandrel above each of the sets of slips for radially expanding the latter in response to relative downward movement of the mandrel, each of said expander cones comprising a plurality of circumferentially spaced cone segments positioned for longitudinal alignment with the related slips, said slip-support collars having longitudinal slots therethrough operable in combination with the spaces between the slips and cone segments to provide fluid by-pass passages between said mandrel and the surrounding well pipe.

2. A liner hanger according to claim **1** wherein said J-slot-and-pin-type connection means includes a pair of inverted J-slots in opposite sides of said cage, and cooperating pins radially projecting from said mandrel into said J-slots.

3. A liner hanger, comprising, a tubular mandrel connectible into a liner string, a tubular slip cage slidably mounted on the mandrel, a J-slot-and-pin connection releasably securing the cage to the mandrel, means carried by the slip cage operable to frictionally engage a surrounding well pipe, said slip cage including two vertically spaced slip-support collars fixedly connected to each other slidably surrounding said mandrel, a set of circumferentially spaced generally rectangular pipe gripping slips mounted about the mandrel above each of said collars, the slips of one set being angularly oriented with respect to those of the other set to align the slips of one set with spaces between the slips of the other set, the widths of said slips and spaces being substantially equal, whereby to effectively form a continuous ring of slip contact area with the surrounding well pipe, spring arms supporting said slips from the respective collars and biasing the slips inwardly toward the mandrel, a downwardly tapering slip expander cone mounted on the mandrel above each of the sets of slips for radially expanding the latter in response to relative downward movement of the mandrel, each of said expander cones comprising a plurality of circumferentially spaced cone segments positioned for longitudinal alignment with the related slips, said slip-support collars having longitudinal slots therethrough operable in combination with the spaces between the slips and cone segments to provide fluid by-pass passages between said mandrel and the surrounding well pipe.

4. A liner hanger, comprising, a tubular mandrel connectible into a liner string, a slip cage including a tubular sleeve slidably mounted on the mandrel, J-slot-and-pin-type connection means securing the sleeve to the mandrel, means carried by the slip cage operable to frictionally engage a surrounding well pipe, said slip cage including two vertically spaced slip-support collars slidably surrounding said mandrel, a plurality of narrow elongate link members supporting the upper one of said collars from the lower one of said collars, a set of circumferentially spaced pipe gripping slips mounted about the mandrel above each of said collars, the slips of one set being angularly oriented with respect to those of the other to align the spaces between one set of slips with the slips of the other set, spring arms supporting said slips from the respective collars and biasing the slips inwardly toward the mandrel, a downwardly tapering slip expander cone mounted on the mandrel above each of the sets of slips for expanding the latter in response to relative downward movement of the mandrel, each of said expander cones comprising a plurality of circumferentially spaced cone segments positioned for longitudinal alignment with the related slips, said slip-support collars having longitudinal slots therethrough operable in combination with the spaces between the slips and said cone segments to provide fluid by-pass passages between said mandrel and a surrounding well pipe, said links extending vertically through the spaces between the slips of said lower set.

5. A liner hanger for well pipes, comprising a tubular mandrel connectible into a liner string, a tubular slip cage slidably mounted on the mandrel, connection means releasably securing the cage to the mandrel, means carried by the slip cage operable to frictionally engage a surrounding well pipe, two vertically spaced sets of circumferentially spaced pipe-gripping slips mounted in fixed longitudinal relation on the cage about the mandrel, means supporting said slips on the cage for radial movement, a downwardly tapering slip expander cone mounted on the mandrel above each of the sets of slips for radially expanding the latter in response to relative downward

movement of the mandrel, each of said expander cones comprising a plurality of circumferentially spaced cone segments positioned for longitudinal alignment with the related slips, the spaces between the slips and cone segments providing fluid by-pass passages between the mandrel and a surrounding well pipe.

6. A liner hanger according to claim 5 wherein said connection means comprises a J-slot-and-pin-type connection means.

7. A liner hanger according to claim 5 wherein the slips of one set are angularly oriented with respect to those of the other set to align the slips of one set with the spaces between the slips of the other set, the widths of said slips and spaces being substantially equal whereby

to effectively form a continuous ring of slip contact area with the surrounding well pipe.

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CHARLES E. O'CONNELL, *Primary Examiner.*