Dec. 10, 1968 S. W. PUTCH 3,415,322

EXPANDABLE BUSHING FOR WELL CASING HANGERS

Filed Oct. 14, 1966 3 Sheets-Sheet 1

FIG_2

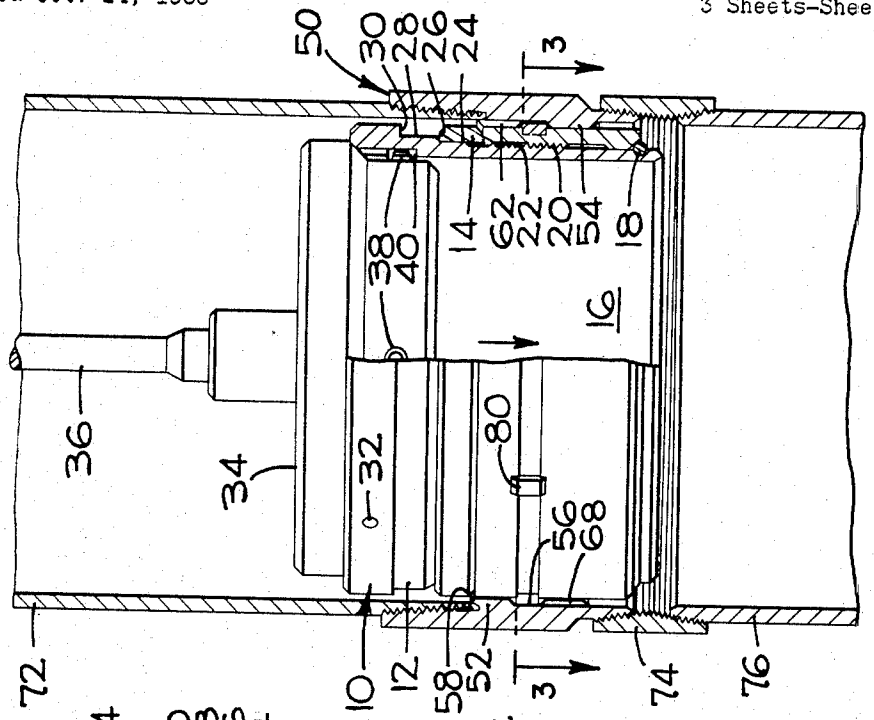
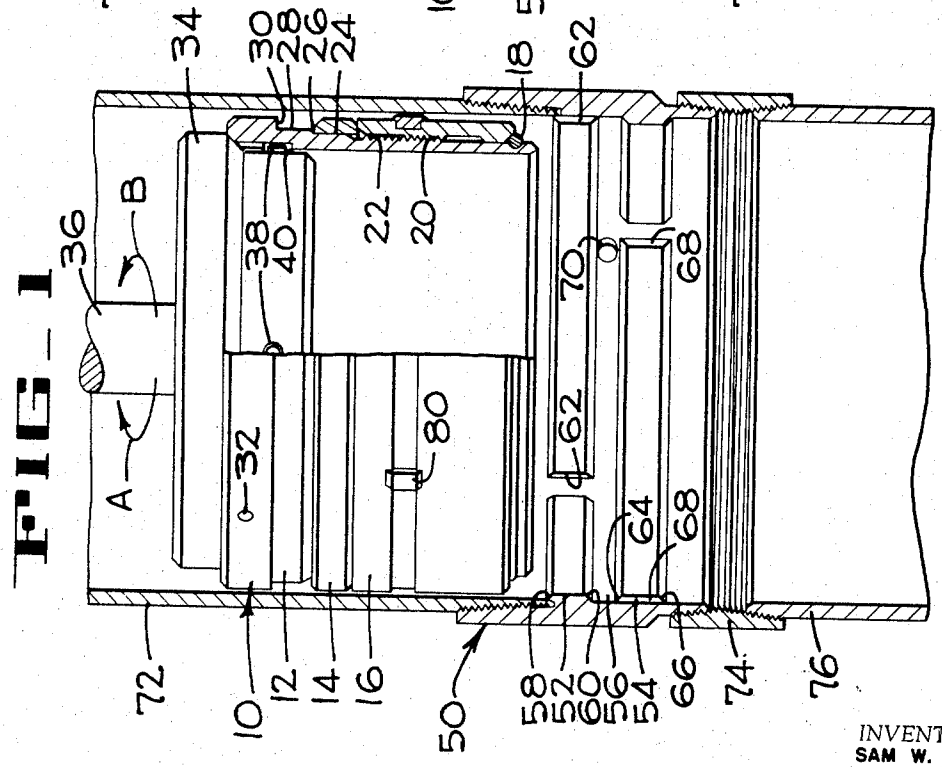


FIG_1



INVENTOR.
SAM W. PUTCH

BY Francis W. Anderson

ATTORNEY

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Filed Oct. 14, 1966 3 Sheets-Sheet 2

FIG_4

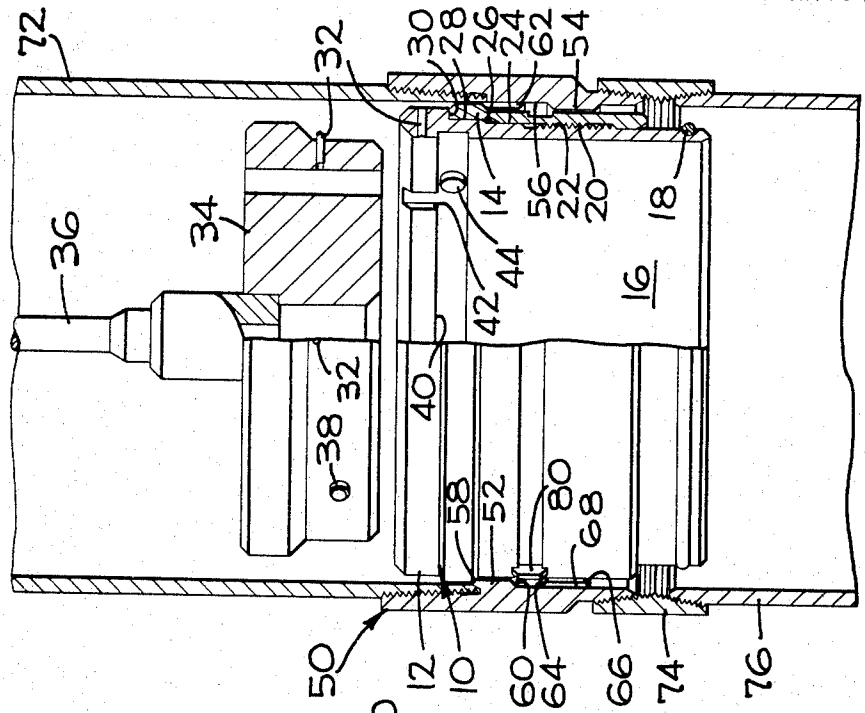
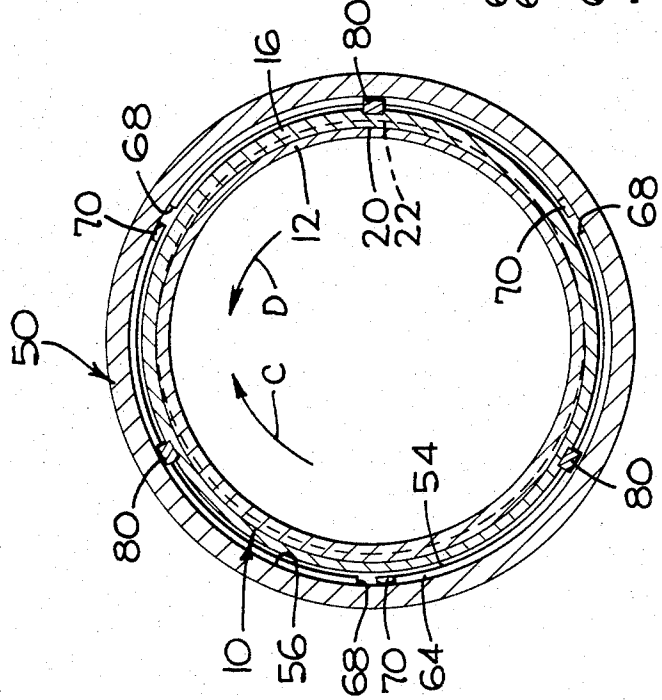


FIG_3



INVENTOR.
SAM W. PUTCH

BY Francis W. Anderson
ATTORNEY

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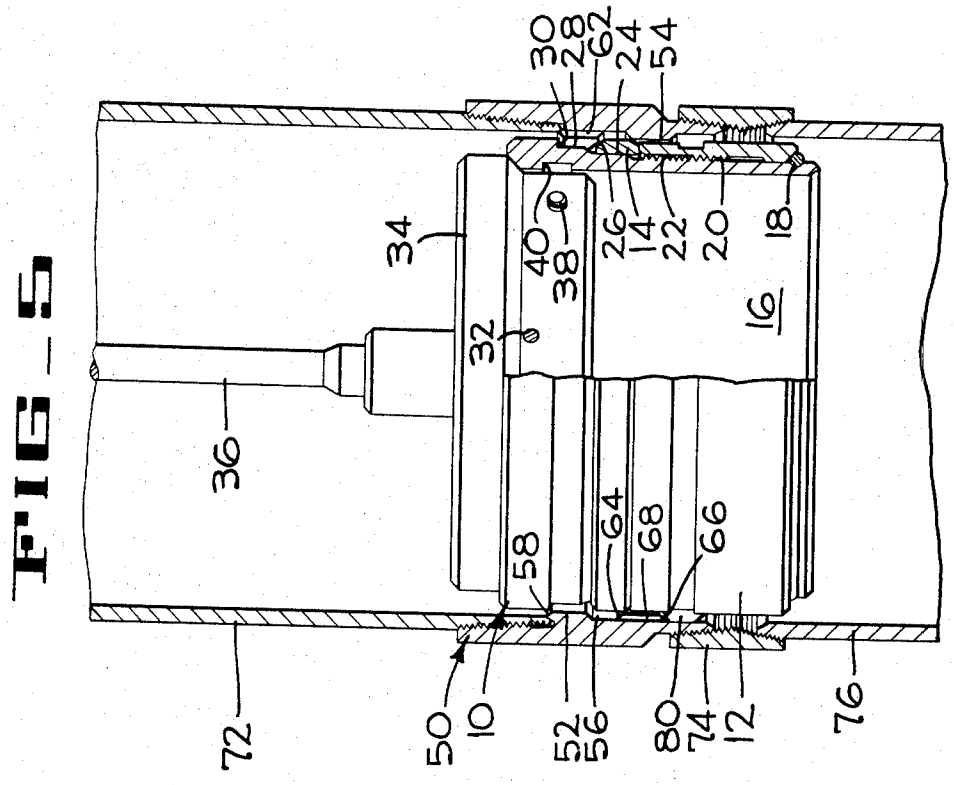
EXPANDABLE BUSHING FOR WELL CASING HANGERS

Filed Oct. 14, 1966 3 Sheets-Sheet 3

FIG_5



INVENTOR.
SAM W. PUTCH

BY Francis W. Anderson
ATTORNEY

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EXPANDABLE BUSHING FOR WELL CASING HANGERS

Sam W. Putch, Houston, Tex., assignor to FMC Corporation, San Jose, Calif., a corporation of Delaware

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ABSTRACT OF THE DISCLOSURE

An apparatus for supporting a string of casing in a well, including a specially-shaped landing sub and a radially-expandable tubular bushing that can be locked in the sub by rotation in one direction to provide a casing support, and passed through the sub by rotation in the opposite direction when the casing support is desired at another level of the well.

This invention relates to a well tool for supporting strings of well casing. More particularly, this invention relates to a bushing which can be expanded into a selected sub or nipple positioned in a well casing to provide support for a hanger for smaller diameter casing strings.

The usual process of drilling a well for the recovery of oil, gas, or other fluids involves lining the well bore with sections or strings of tubular casing of progressively smaller diameter to prevent the bore from caving, to forestall entry of undesirable fluids, to enhance production operations, and for various other reasons. It is very important that the outermost or surface casing be firmly anchored or set in a competent or structurally sound and strong formation, for the surface casing also acts as a foundation for all the other casing strings which, in a well based on firm ground, are all anchored to its top or head. However, when drilling at off-shore locations or on swampy or otherwise unsound land, the water and the adjacent underlying earth formations through which the surface casing must extend provide it with practically no support, and it must be driven into deeper competent formations until the needed support is found. That unsupported portion of the surface casing between the deeper competent formation and the wellhead is subject to considerable stress and strain, especially in a lateral direction as a result of water motion, and placing the additional burden of the weight of the inner casing strings upon this portion greatly increases the danger of it collapsing.

To overcome this problem the practice has been to anchor the casing strings to the surface casing as close as possible to the area where the surface casing is adequately supported by a competent formation. Since it usually is not possible to accurately foretell where this area will be, and thus how much casing will be required to reach it, a difficult problem exists in properly prepositioning a casing string anchoring device or hanger in the surface casing before running it in the well. On the other hand, installing a casing hanger after the surface casing has been set in the competent formation can be equally difficult even with the best tools heretofore available.

The foregoing problems are overcome by the present invention which, in summary, involves a new type of expandable casing hanger bushing and a landing sub especially adapted to receive the bushing and either hold it so that it can in turn provide support for an inner casing string, or permit it to pass through and on to another more desirable level in the well. Whether the bushing is held in or passes through the sub is dependent upon the direction in which the bushing is rotated, so that by including a plurality of subs spaced at selected intervals in the outer casing, the inner casing can be hung

at any chosen level in the well. This facility for holding or passing the bushing results from a novel connection between the bushing and the sub, and includes a plurality of external ears radially projecting from the bushing to contact with a pair of annular shoulders, and a slot and groove pathway through the shoulders with stops to control the extent of rotation of the bushing in either direction.

Accordingly, an object of the present invention is to provide a new system for accurately positioning and securely anchoring well casing strings to a surface casing.

Another object of the present invention is to provide a new system for positioning a well casing hanger at any of a number of pre-established locations in a surface casing after the surface casing has been set.

Another object of the present invention is to provide a bushing and a cooperating landing sub for anchoring a casing string hanger to a surface casing, which bushing can be easily positioned in the sub at the desired location after the surface casing has been set.

Still another object of the present invention is to provide an expandable bushing for supporting inner casing hangers inside an outer well casing, and a landing sub adapted for connecting into the outer casing and receiving the bushing which can be run in the well and set in the sub with drill pipe or other conventional well drilling equipment.

Yet another object of this invention is to provide an expandable casing hanger bushing which can be set in its landing sub by a simple rotating motion.

A still further object of the present invention is to provide a new procedure for positioning an inner casing string anchor device at a desired location in a surface casing.

The foregoing as well as further objects and advantages of the present invention will become readily apparent from the following description of a device constructed in accordance therewith, and from the accompanying drawings thereof, in which:

FIGURE 1 is a view in side elevation, and partially in section, of an expandable bushing and its cooperating landing sub according to this invention, the sub positioned between two lengths of well casing and the bushing resting in the casing above the sub;

FIGURE 2 is another view of the bushing and sub of FIGURE 1, showing the bushing after it has been lowered into the sub from its position in FIGURE 1, and before it has been rotated and expanded into locking engagement with the sub;

FIGURE 3 is a view in cross-section, taken along the line 3—3 of FIGURE 2, showing the positions of the bushing's landing ears in relation to the slots and stop pins on the sub;

FIGURE 4 is a view of the bushing and sub of FIGURES 1 and 2, showing the bushing after it has been rotated clockwise and set in the sub, and also showing the running tool after it has been withdrawn from the bushing; and

FIGURE 5 is a view similar to FIGURES 1, 2 and 4, showing the bushing after it has been rotated counterclockwise, partially passed through the sub, and positioned for lowering further into the casing.

Broadly considered, as illustrated in the drawings the expandable bushing **10** of the invention comprises an elongate annular housing **12**, an annular lock ring **14** slidably circumscribing and carried by the housing **12**, an annular expander **16** rotatably circumscribing the housing **12**, and an annular retainer ring **18** circumscribing and tightly gripping the housing **12** to retain the expander on the housing.

The expander **16** is threaded along a portion of its internal surface at **20**, and the underlying portion of the

external surface of the housing **12** has corresponding threads **22**. Thus, rotating the housing **12** while the expander **16** is stationary will cause the housing to travel axially within the expander. The threads **20**, **22** preferably are right handed so that when the housing **12** is rotated clockwise when viewed from above, i.e., in the direction of arrow C in FIGURE 3, the housing will move downwardly in the expander as indicated by the arrow in FIGURE 2.

The housing **12** has an annular retainer surface **24** upon which the lock ring **14** is carried in its retracted condition as shown in FIGURES 1, 2 and 5. From the upper edge of the retainer surface **24** an inclined annular expanding surface **26** extends upwardly and outwardly to an annular locking surface **28** of larger diameter than the retainer surface **24**. A retainer flange **30** extends outwardly from the upper limit of the locking surface **28** to provide a stop against which the expandable lock ring **14** bears when it is in locking position on the surface **28** (FIG. 4).

The expandable bushing **10** is designed so that it can be removably attached to a drill string or other suitable pipe through a conventional running tool. This is implemented primarily by a plurality of shear pins **32** spaced equally around the upper end of the housing **12** and extending through ports in the housing into coinciding ports in a running tool **34**, which tool is attached in a conventional manner to the drill string or pipe **36**. Accordingly, when the expandable bushing **10** has been set in place (FIG. 4), the running tool **34** can be disconnected and recovered merely by lifting upon the drill string or pipe **36** and shearing the pins **32**.

The expandable bushing **10** has been designed to cooperate with conventional running tools which contain a plurality (usually four) of equally spaced locking ears **38** that fit into corresponding slots and grooves in the well devices which they handle, and by rotating the tool and either lifting up or letting down on it the connection between the device and the tool can be broken or established, respectively. This is facilitated with the expandable bushing **10** by an inner annular groove **40** in the upper end of the housing **12**, a plurality of slots **42** of equal spacing and number with the ears **38** on the running tool **34**, and a like number of stop pins **44** (FIGURE 4; only one shown) projecting radially inward from the groove **40** and tangentially adjacent to the slots **42**. Thus, when the running tool **34** is inserted into the housing **12** until the ears **38** are in the groove **40**, and then rotated counterclockwise or to the left as indicated by arrows B (FIG. 1) and D (FIG. 3), the ears **38** will travel around the slot **40** and come to rest against the stop pins **44**, locking the tool **34** in the housing **12**. As shown by arrows A and C, clockwise rotation until the ears **38** come to rest against the opposite sides of the pins **44** places the ears **38** directly in line with the slots **42**, and the tool **34** can then be withdrawn from the housing **12** by simply lifting it out. This system provides a secondary or back-up procedure for running in and setting the expandable bushing **10** in the event the shear pins **32** accidentally give way prematurely.

The expandable bushing **10** and its landing sub **50** are designed so that the bushing **10** can be either set or passed through the sub **50** as desired. The landing sub **50** is annular in shape and comprises a pair of spaced internal upper and lower shoulders **52**, **54**, respectively, defining between them a groove **56**. The upper shoulder **52** has upper and lower beveled ledges **58**, **60**, and three slots **62** spaced 120° from each other. In similar manner, the lower shoulder **54** has upper and lower beveled ledges **64**, **66**, and three slots **68** spaced 120° with respect to each other and 60° with respect to the slots **62**, as shown in FIGURE 1. Stop pins **70** project radially inward from the groove **56** tangentially adjacent to the slots **68**. The landing sub **50** is threaded internally at its upper end for connecting it to a length of well casing **72**, and threaded exteriorly at its lower end for connecting it to a conventional casing coupling **74**, which, in turn, is threadedly connected to another length of well casing **76**.

As has been mentioned previously, the expandable bushing **10** can be set in the sub **50** by a simple rotating motion. The bushing **10** is lowered through the casing **72** until the landing ears **80** which extend outwardly from the expander **16** contact the upper ledge **58** of the sub's upper shoulder **52**. Carrying the bushing **10** with it, the drill pipe is then rotated clockwise, i.e., to the right as shown by arrow A in FIGURE 1, until the ears **80** move over and drop through the slots **62**, coming to rest on the upper ledge **64** of the sub's lower shoulder **54** (FIGS. 2 and 3). The drill pipe and the bushing then are again rotated clockwise, as indicated by arrow C of FIGURE 3, until the ears **80** contact the sub's stop pins **70** in the groove **56** and prevent further rotation of the expander **16**. Continuing clockwise rotation of the drill pipe then rotates and threads the housing **12** into the expander **16** and forces the housing's expanding surface **26** through the lock ring **14**, camming the ring out onto the sub's locking surface **28** and seating the housing's stop flange **30** onto the ring's upper surface. The running tool **34** is then removed by lifting up on the drill pipe as described above.

When it is desired to pass the bushing **10** through the sub **50**, such as when several subs have been spaced in the casing in an effort to end up with at least one in the area where the casing is adequately supported by a competent formation, and the selected sub is beneath one or more upper subs, the bushing is lowered in the same way until the landing ears **80** contact the sub's shoulder **52**. The drill pipe is then rotated counter-clockwise or to the left (as shown by arrow B in FIG. 1) until the ears **80** drop through the slots **62** and continue in this direction around the slot **56** to contact the stop pins **70**. At this position the ears **80** are directly above the slots **68** in the sub's lower shoulder **54**, and letting down on the drill pipe will let these ears pass through the slots (as shown in FIGURE 5) and on into the lower section of casing **76**. The bushing can then be lowered to the next sub and either set or passed through it as desired.

Thus, merely by including a sufficient number of subs in the casing so that when the casing is set at least one of the subs is at or near enough to the desired competent formation, the bushing can be set at this formation regardless of its distance from the wellhead or the number of subs through which it must pass.

Although a rather flat, split-ring type of lock ring, a three slot-and-ear system, and a four-eared running tool have been described and illustrated, these may all be modified in various ways that will be apparent to those skilled in the art without departing from the scope of the invention.

Although the best mode contemplated for carrying out the present invention has been herein shown and described, it will be apparent that modification and variation may be made without departing from what is regarded to be the subject matter of the invention as set forth in the appended claims.

I claim:

1. An expandable bushing for providing support for well tools in a tubular housing, comprising:

(a) an elongate, annular housing having an external annular stop flange, an external annular retainer surface axially spaced beneath said stop flange and having a first diameter, an external annular locking surface between said stop flange and said retainer surface and of a second diameter larger than said first diameter, and an external annular tapered expanding surface extending outwardly and upwardly from said retainer surface to said locking surface;

(b) an annular lock ring slidably circumscribing and carried by said housing beneath said stop flange and adapted to move axially from a normally contracted condition surrounding said retainer surface, over said

expanding surface and onto said locking surface into an expanded and tool supportive condition;

(c) an annular expander rotatably circumscribing said housing and disposed beneath said lock ring;

(d) means for moving said expander axially on said housing; and

(e) an annular retainer ring circumscribing and gripping said housing beneath said expander.

2. The bushing of claim 1 wherein the expander contains a plurality of landing ears evenly and circumferentially spaced around its outer surface.

3. The bushing of claim 1 wherein the expander and the housing are threadedly interconnected such that rotating the housing while holding the expander stationary will move the housing axially in the expander.

4. The bushing of claim 1 wherein the housing is adapted for connection to a running tool through a shear pin system.

5. The bushing of claim 1 wherein the housing is adapted for connection to a running tool through a mating pin and slot system.

6. A landing sub for an expandable bushing for providing support for well tools in a tubular housing, comprising an annular sleeve with a pair of axially spaced, radially projecting, internal upper and lower annular shoulders having upper ledges adapted for supporting landing ears on said expandable bushing, each of said shoulders having a plurality of evenly spaced axially-extending slots for passing said bushing through said sub, the slots of said upper shoulder being offset circumferentially from the slots of said lower shoulder; and at least one stop means projecting radially inwardly from between said shoulders adjacent one of the slots in said lower shoulder and circumferentially spaced from the next adjacent upper shoulder slot, whereby when said expandable bushing is positioned in said sub with said ears between said shoulders and axially aligned with the slots in said upper shoulder, rotation of said bushing in one direction until an ear contacts said stop means will axially align said ears with the slots in said lower shoulder to thereby facilitate axial movement of said bushing past said lower shoulder, and rotation of said bushing in the opposite direction until an ear contacts said stop means will restrict said bushing against axial movement past either shoulder, thereby locking said bushing in said sub.

7. In combination, an expandable bushing for providing support for well tools in a tubular housing, and a landing sub for said bushing, said bushing comprising:

(a) an elongate, annular housing having an external annular stop flange, an external annular retainer surface axially spaced beneath said stop flange and having a first diameter, an external annular locking surface between said stop flange and said retainer surface

and of a second diameter larger than said first diameter, and an external annular tapered expanding surface extending outwardly and upwardly from said retainer surface to said locking surface, said housing being adapted for connection to a running tool through a shear pin system and a mating pin and groove system;

(b) an annular lock ring slidably circumscribing and carried by said housing beneath said stop flange and adapted to move axially from a normally contracted condition surrounding said retainer surface, over said expanding surface and onto said locking surface into an expanded and tool supportive condition;

(c) an annular expander circumscribing said housing and disposed beneath said lock ring, said expander having a plurality of circumferentially-spaced landing ears extending outwardly from its outer surface, said expander being threadedly interconnected to said housing; and

(d) an annular retainer ring circumscribing and gripping said housing beneath said expander;

said landing sub having a pair of internal, radially projecting annular shoulders adapted to support said bushing, said shoulders having a plurality of circumferentially-spaced axially-extending slots for receiving said ears to pass said bushing through said sub.

8. The combination bushing and sub of claim 7 wherein said shoulders of said sub contain a plurality of axially-extending, circumferentially-spaced slots corresponding to said landing ears on said bushing expander, said slots of one shoulder offset from said slots of the other shoulder, and a plurality of inwardly projecting stop pins between said shoulders positioned tangentially adjacent said slots of one shoulder.

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

IAN A. CALVERT, *Assistant Examiner.*

U.S. Cl. X.R.

166—242; 285—141, 402