Sept. 10, 1968 H. O. QUEBE ET AL 3,400,950

STAB-IN CONDUIT COUPLINGS

Filed May 26, 1966 2 Sheets-Sheet 1

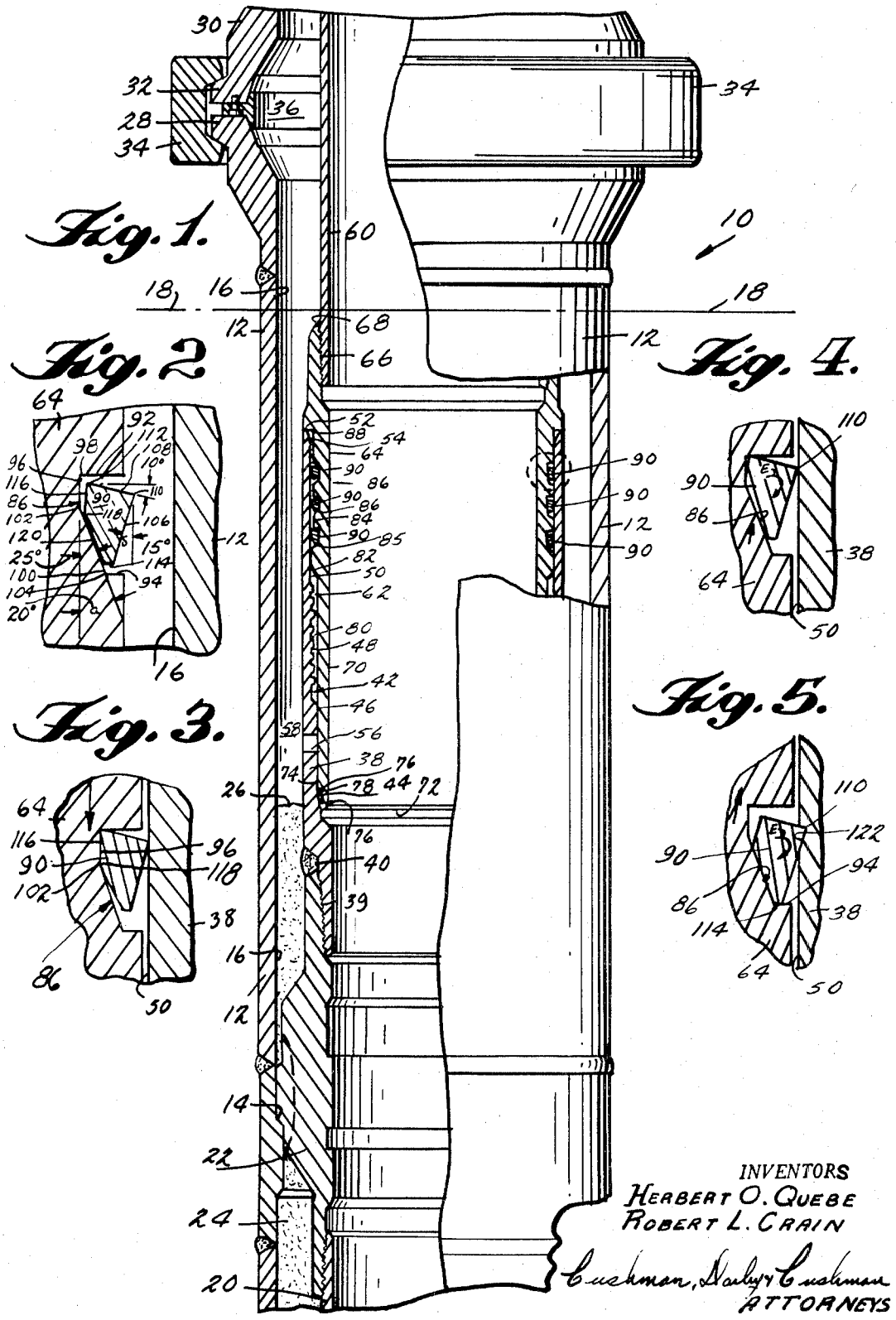


Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

INVENTORS
HERBERT O. QUEBE
ROBERT L. CRAIN

Cushman, Darby & Cushman
ATTORNEYS

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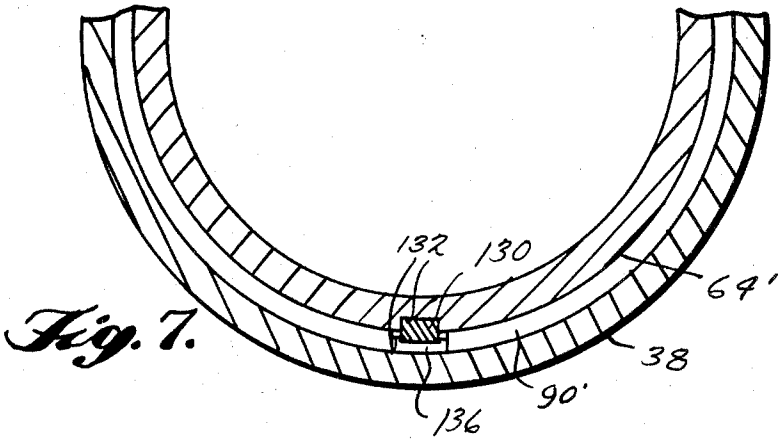
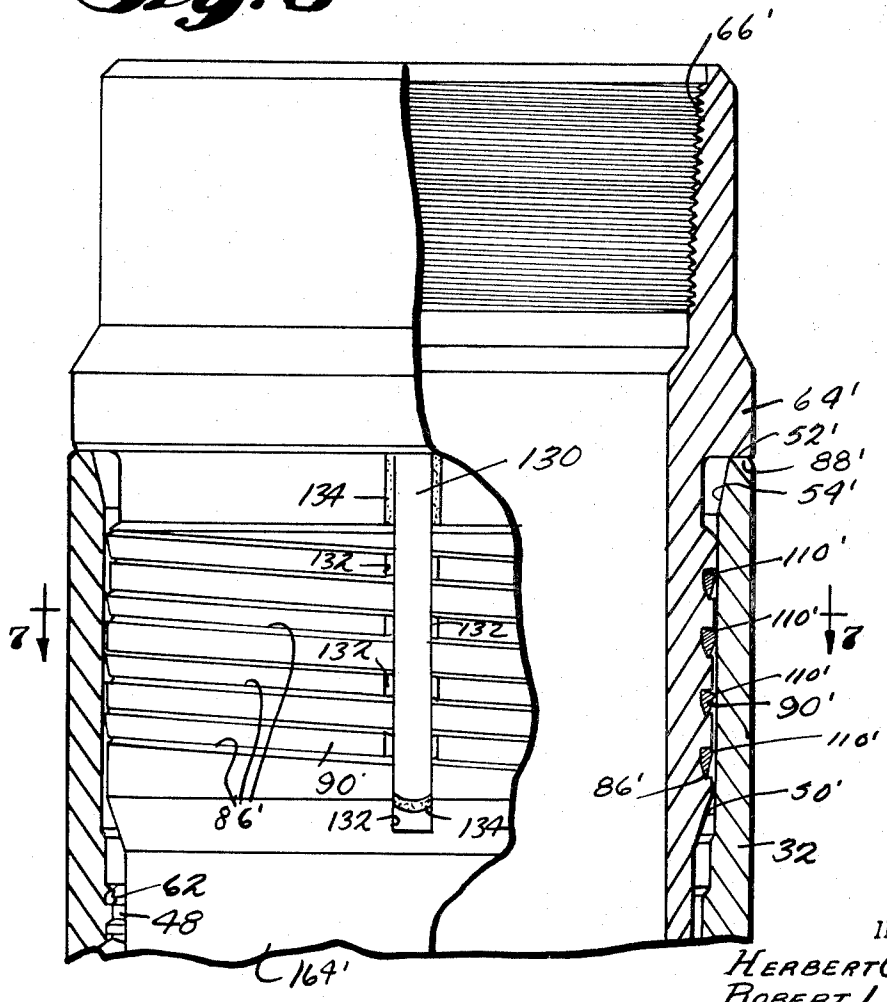


Fig. 7.

Fig. 6



INVENTORS
HERBERT O. QUEBE
ROBERT L. CRAIN
Cushman, Darby & Cushman
ATTORNEYS

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STAB-IN CONDUIT COUPLINGS

Herbert O. Quebe and Robert L. Crain, Houston, Tex., assignors to Gray Tool Company, Houston, Tex., a corporation of Texas

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ABSTRACT OF THE DISCLOSURE

A stab-in tie-back sub for reestablishing communication with the cylindrical bore of a sub-sea well conduit comprising a tubular fluid confining element; means defining at least one circumferential groove in the exterior of said element and opening radially outwardly thereof, a unitary circumferentially extending slip received in said groove and protruding radially outwardly therefrom; means defining a circumferential inclined plane on said slip facing radially outwardly and slightly downwardly and having an upper edge portion arranged to frictionally engage and slide along the sub-sea well conduit bore when the sub is lowered into the bore, means defining a circumferential upwardly and outwardly facing surface on said slip intersecting said inclined plane at said upper edge portion and defining a sharp circumferential ridge on said slip at the intersection; and camming means between said groove and said slip responsive to incipient withdrawal of said sub from said sub-sea well conduit for moving said ridge angularly clockwise and radially outwardly into gouging engagement with said sub-sea well conduit.

The present invention relates to stab-in conduit couplings particularly useful for tying back into sub-sea, temporarily abandoned petroleum wells.

Background of the invention

In the commonly assigned, co-pending U.S. patent application of Pitts et al., Ser. No. 539,242, filed Feb. 18, 1966, a development relating to hanging casing in sub-sea wells near the mud line so that particular wells can be temporarily abandoned upon substantial completion, during the time that nearby formation definition wells are being drilled to determine if there is a sufficient amount of recoverable petroleum in the area to warrant installation of production, collection, temporary storage and/or other similar equipment necessary to produce from the wells. One important feature of the development disclosed therein is means for separating all of the conduit risers from their respective casing strings just above the near-the-mud-line hangers so that a temporary abandonment cap can be placed on the well so near the mudline that the temporarily abandoned well is not a hazard to navigation.

The exemplary means shown in that application comprise coarse cooperative threading, for instance, two pitch acme threads adjacent the ends of the parts to be separated.

Although the development just described has proved to be very successful in facilitating completion, temporary abandonment and tying-back into temporarily abandoned wells, the present invention grew out of anticipation that between separation of risers from mudline suspended casing strings to effect temporary abandonment and tying back into such wells, the threading on the upper ends of the sub-sea parts could become so damaged that a threaded reconnection could not be made.

Summary of the invention

Accordingly, a major object of the present invention is the provision of means for tying back into remote conduits such as mud-line suspended casing strings, sub-sea

casing hanger housings and the like, which do not require relative rotation between the parts to be connected in order to form a sealed connection, even if previously used threading has become severely damaged.

A further object of the present invention is the provision of apparatus of the type described which is susceptible of reseparation by relative rotation of the connected parts.

Recognizing that the invention has broader applicability than to solution of the specific problem just outlined, it is an object of the present invention to provide an improved stab-in joint for conduits or other parts such as pressure vessel-pressure vessel closure arrangements, rod to socket couplings and the like.

These and further objects of the present invention as well as the principles and scope of applicability of the invention will become more clearly apparent during the following detailed discussion relating to the exemplary embodiments depicted in the attached drawings.

Brief description of the drawings

In the drawings:

FIGURE 1 is a fragmentary side elevation view of two conduits coupled to one another at a stab-in joint according to the present invention, one quadrant of the conduits being broken away to expose details of the joint that would otherwise be hidden;

FIGURES 2–5 comprise expanded scale, detail views of the substantially area phantom-line circled in FIGURE 1 showing various successive stages in making-up the joint shown completed in FIGURE 1;

FIGURE 6 is a fragmentary elevation view of the upper mid-region of a modification of the apparatus of FIGURE 1, the slips comprising a continuous spiral, a key being provided to prevent angular translation of the slips along the tie-back sub; in FIGURE 6 parts are cut away to expose details of the key; and

FIGURE 7 is a transverse cross-sectional view substantially along line 7—7 of FIGURE 6.

Description of the preferred embodiments

The sub-sea well **10** of FIGURE 1 includes an outer casing **12** driven to refusal in the sub-sea earth. The casing **12** has a casing hanger support seat **14** formed in its bore **16** about 20 feet below the mud line **18**. An inner casing string **20** is shown suspended via a hanger **22** from the seat **14** and the inter-casing annulus **24** cemented up to **26**. It should be noticed that both the hanger **22** and outer casing **12** terminate about five feet below the mud line **18** and for the purpose of better understanding of the invention, the well **10** should be assumed to have been temporarily abandoned after the casings **12** and **20** were emplaced and cemented, by detaching all risers and installing a temporary abandonment cap as disclosed in the above-mentioned Pitts et al. application and that at the point shown in FIGURE 1, the temporary abandonment cap has been removed, and operations begun to tie back, i.e. to reconnect conduits to the sub-sea well structure in order to allow further drilling and/or completion of the well to recommence. Specifically, the outer casing **12**, which terminates in a wedge-like flange **28** has been connected to a riser **30** having a similar wedge-like flange **32** at its lower end by a remotely operable expansible-contractile clamp **34**, sealing being provided between these parts by a flanged, two deflectable lip sealing ring **36** secured to the lower end of the riser **30**. The ring **36** is of the type shown in commonly assigned U.S. Patents 2,766,-829; 2,766,998 and 2,766,999. The riser **30** extends up to the surface where drilling and completion operations are conducted from a platform, vessel or the like, the riser **30** serving to isolate the sea from the well, provide a conduit for lowering and raising of parts, for confining fluids and

for mounting of well control equipment such as blowout preventor stacks at the surface.

It should be noticed that the hanger **22** has an axially upward annular extension **38** fixed to it by threading **39** circumferential welding at **40**. The bore **42** of the extension enlarges upwardly at **44** to define a frusto-conical sealing surface is cylindrically curved at **46**, then threaded at **48** with, for instance, two pitch acme threads is cylindrically curved again at **50** between the threads **48** and adjacent the hanger **22** extension flat upper end **52** which defines a stop shoulder. Closely adjacent and leading to the end **52** the bore **42** flares frusto-conically to define a guide surface **54**. A plurality of angularly spaced circulation ports **56** used following the cementing operation to circulate out excess cement from the region **58** to the surface, are formed through the hanger extension **38** axially intermediate the surface **46**.

In the usual course of events, personnel tying back into the well **10** could expect to be able to lower a riser **60** with an exteriorly threaded, tapered nosed sub (not shown) at its lower end through the riser **30** and into the bore **42** for threaded engagement with the threads **48** so that further drilling or other operations can be recommenced through and below the inner casing string **20**. For the sake of further explanation of the present invention let it be assumed that such tie back procedure has been attempted, but due to damaging at **62** of the hanger extension threads **48**, such a connection cannot be satisfactorily made. The riser and threaded sub are then withdrawn to the surface and a novel stab-in tie-back sub **64** according to the present invention installed on the lower end of the riser **60**, for instance by complementary threading at **66** and circumferential welding at **68**.

The tie-back sub **64** is generally tubular having a longitudinal throughbore **70**. From its lower end or nose **72**, the sub **64** exterior is first upwardly enlarging frusto-conically curved at **74** complementarily to, or slightly less steeply than, the hanger extension surface **44**. One or more (two shown) circumferential recesses **76** in the surface **74** receive hard hydraulic packing **78** which in its free state protrudes radially outwardly slightly beyond the surface **74**. Above the surface **74**, the sub **64** exterior is cylindrically curved at **80**, having a radius slightly smaller than that of the surface **46** and extending axially to above the threading **48** when the parts are positioned as shown in FIGURE 1. Then the sub **64** exterior frusto-conically enlarges at **82** and is circumferentially curved at **84**. The portion **84** has a radius slightly smaller than that of the surface **50** and is interrupted at several points (three shown) by circumferential radially outwardly opening annular axially spaced grooves **86**. At the upper extent of the surface **84**, the sub **64** exterior radially enlarges forming an annular, downwardly facing, positive stop shoulder **88** which functions to positively limit the extent of stabbed insertion of the sub **64** into the hanger extension internal bore **44**. The stop shoulder **88** is positioned, relative to the frusto-conical surface **74** to engage the hanger stop **52** when the sealing material **78** has been compressed to flushness by coextensive engagement of the surfaces **44** and **74** and thus prevent over-compression of the sub lower end seal.

As best seen in FIGURE 1, the exterior of the stab-in tie-back sub **64** is smooth radially adjacent the damaged threading **48** and radially smaller so that the threading **48** is not used in effecting securement of the sub **64** to the hanger extension **38**. Instead, slip rings **90** received in the grooves **86** provide the required securement as will now be more fully explained, having reference to FIGURES 1–5.

Each groove **86** is shown delimited at its upper extent by a radially directed surface **92** and at its lower extent by a radially directed surface **94** of approximately half the radial extent of the surface **92**. A generally cylindrically curved surface **96** extends from the apex **98** at the radially inner extent of the surface **92** about one-third the distance toward the surface **94** and a generally frusto-conical surface **100** extends from the apex **102** at the lower extent of the surface **96** to an apex **104** at the radially inner extent of the surface **94**. The surface **100** is canted at an angle α of about 20 degrees.

With reference to FIGURE 2, each ring **90** is shown having a radially inner, frusto-conically curved surface **106** canted about minus 15 degrees (angle δ) with respect to the longitudinal axis of the sub **64**. At its upper extent, the surface **106** is intersected at approximately a right angle by the ring upper surface **108** defining a ridge or apex **110**. The surface **108** proceeds radially inwardly and upwardly at about a 10 degree angle γ, rounding or leveling off at **112** adjacent and leading to, its radially inner upper extent. At its lower extent, the surface **106** is intersected at approximately a 105 degree angle by a radially short lower surface **114**. The ring lower surface **114** is about one-half to one-third as wide as the groove lower surface **94**, but the ring upper surface **108** is about 20 percent greater in width than the groove upper surface **92**.

A first radially inwardly facing ring surface **116** extends between the point **112** and an apex at **118** intermediate the upper and lower extent of the ring where it joins a second inwardly facing surface **120** that proceeds to a juncture with the radially inner extent of the ring lower surface **114**. As positioned in FIGURE 2, the surface **116** is generally cylindrically curved and of approximately the same axial length as or slightly shorter than the groove surface **96** and the surface **120** is canted at about 25 degrees (angle β) with respect to the longitudinal axis of the sub **64**. It should also be noticed with respect to the FIGURE 2 condition, that the total vertical height of the ring is about 20 percent shorter than the vertical distance between the groove upper and lower surfaces **92**, **94** and that in the "at rest" position of FIGURE 2, the ring **90** rides intermediate the upper and lower surfaces of the groove with room for movement upwardly as well as downwardly from the position shown.

The rings **90** can each be radially split at a stage in their manufacture so as to be readily radially expansible sufficiently to be snapped into the respective grooves **86** as the sub **64** is being made up. When snapped in place, the ends of the rings should engage or nearly engage when in condition thereof so that the rings will function properly throughout the sequence illustrated in FIGURES 3–5.

A sub **64**, made up as just described and with rings **90** positioned as shown in FIGURE 2 is lowered via the riser or pipe **60** into the riser **30** and downwardly through the casing **12** bore **16**. The tapered nose **72** is guided into the hanger extension bore **42** by the flared end region **54** of the bore.

As lowering continues, the ring apices **110** causing the rings to move slightly inwardly and upwardly as shown in FIGURE 3 until the points **112** engage the respective upper surfaces of the grooves **86**. At this point, the ring apices **118** are nestled in the respective groove apices **102** and the ring surfaces **116** coextensively engage the respective groove surfaces **96**. In this downward movement the ridges **110** do not "plow" into the hanger extension bore surface **50** because of the comparative lowness of the angle δ, but rather are "shoe-horned" along this surface. Engagement at **52**, **88** terminates downward movement of the sub **64** and prevents over-running of the seal formed at **44**, **74**. The weight of the pipe **30** is sufficient to bring the sub to the stabbed-in stopped and locked condition shown in FIGURE 1. Any tendency of the sub **64** to move upwardly from the FIGURE 1 position causes the rings **90** to angularly rotate (arrow ϵ) about the apices **118**, as progressively shown in FIGURES 4 and 5, forcing the sharp edges **110** to bite into the wall of the hanger body **38** (FIGURE 4) and moving the surfaces **100** and **120** into engagement. Further upward movement of the sub **64** (FIGURE 5) causes the rings **90** to be cammed radially outwardly as the surfaces **100** slide along the re-

spective surfaces **120** thereby forming substantial bites or tapered annular sockets **122**. Relative movement is positively stopped when the ring surfaces **114** engage the groove surfaces **94**. The entire upward movement of the sub **64** between FIGURE 3 and FIGURE 5 in the illustrated example is only about three thirty-seconds of an inch and is insufficient to break the seal at **44, 78**.

It should now be apparent that the hanger body **22, 38** has been tied back into efficiently irrespective of the damaged threading at **62** and that further completion of the well **10** can now be undertaken. The slips **90** are considered advantageous because they operate within conventional interelement radial spacing, are self-energizing and not susceptible to easy failure, are quick acting and require a minimum of vertical relative movement to set, are easy to manufacture and assemble, and have broad applicability.

It should be appreciated that the slips **90** must be made of sufficiently tough material that they will gouge the wall of the hanger body extension rather than being plastically deformed themselves. Aside from this consideration, many materials can be used to fabricate the slips **90** and accordingly the following examples of properties should be considered in a non-limitative sense.

Part	Fig. 1 numeral	Material	Rockwell Hardness
Hanger body extension	38	AISI 4130	30 "C"
Slip rings	90	AISI 4140	65 "C"
Sub	64	AISI 4130	30 "C"

A modified stab-in tie back sub **64'** is illustrated in FIGURES 6 and 7 received in the bore of a hanger body **38** as in FIGURE 1. The sub **64'** differs from the sub **64** by having a single multiple turn, spiral groove **86'** rather than a plurality of individual, annular grooves; in having a single spiralled slip **90'** received in the groove **86'** and in having a key **130** mounted so as to prevent translation of the slip **90'** along the groove **86'**. In other respects, the two subs are structurally alike and the slip **90'** functions during tie back operations as described in relation to FIGURES 2–5. Accordingly, corresponding parts have been given primed numerals.

After the slip **90'** has been disposed in the groove **86'** means are provided to prevent relative angular rotation between the slip and the groove. In the embodiment illustrated, the sub exterior and slip have been grooved at **132** with a longitudinally elongated, arcuately narrow, radially outwardly opening channel that is cut approximately halfway through the slip **90'** a key in the form of a strap **130** is received in the channel **132** overlying the slip **90'** and welded to the sub **64'** at **134**, its opposite end regions. As best seen in FIGURE 7, the strap **130** is insufficiently thick to engage the hanger body bore, there being a gap **136** between the radially outer surface of the strap and the bore. The structure shown is preferred because it results in positive locking of each turn of the spiralled slip **90'**, however, it is intended to be exemplary in the sense that other slip locking means could be employed, such as depositing weld material in the channel **86'** immediately adjacent the two ends of the slip **90'**.

Referring to FIGURES 4, 5 and 6, it should be apparent that the slip **90'** corner **110'** cuts a spiralled gouge or groove in the hanger body wall, rather than annular grooves **122** as it is non-rotatively stabbed into place. Accordingly, if the need should arise to disengage the sub **64'** from the casing hanger body **38**, this can be easily achieved by rotating the sub **64'** with respect to the casing hanger body, whereupon the slip **90'** corner **110'** spirals along the groove it has cut in the hanger body wall and the parts are as simply threadably disengaged as if they had been conventionally prethreaded parts. The fabrication materials for the FIGURE 6 and 7 embodiment can be the same as those described above in relation to the embodiment of FIGURES 1–5.

It should now be apparent that the embodiments described hereinabove clearly illustrate the principles of the present invention and that the invention achieves each of the objects set forth at the outset of this specification. Because the specific embodiments can be considerably modified without departing from these principles or failing to accomplish these objects, the present invention should be understood as encompassing all such modifications as are within the spirit and scope of the following claims.

We claim:

1. In combination: a first part having means defining a generally cylindrical bore therein communicating with the exterior of the first part at means defining a mouth; a second part constructed and arranged to be stabbed into said bore through said mouth; and securement means received between said first and second parts for preventing non-rotative withdrawal of the second part from the bore of the first part; the securement means comprising: means defining at least one circumferential groove in one part opening toward the other part of said first and second parts; a unitary circumferentially extending slip received in said groove and protruding therefrom toward said other part; said slip extending about at least one half the circumference of said one part; means defining a circumferential inclined plane on said slip facing away from said mouth and constructed and arranged to frictionally engage said other part and ease advancement of the second part in the first part bore; means defining a sharp circumferential ridge on said slip at the trailing edge of said circumferential inclined plane; and camming means between said groove and said slip responsive to incipient withdrawal of said second part from the bore of said first part for moving said ridge into gouging engagement with said other part; said ridge being composed of harder material than said other part; said groove being axially wider than said slip and the camming means comprising means defining a first canted circumferential surface on said one part within said groove, said first canted surface facing both said other part and said mouth and a second canted surface on said slip facing both away from said other part and away from said mouth; said second canted surface being engageable with and slidable along said first canted surface; said second canted surface being canted slightly more than said first canted surface with respect to the longitudinal axis of said bore; and further including means defining a first generally cylindrically curved surface on said one part within said groove extending generally parallel to said longitudinal axis from a first line intersection with said first canted surface toward said mouth, said first line intersection defining a first circumferential apex, and means defining a second generally cylindrically curved surface on said slip extending generally parallel to said longitudinal axis from a second line intersection with said second canted surface toward said mouth, said second line intersection defining a second circumferential apex; said first and second generally cylindrically curved surfaces being of approximately equal axial length; said slip having a rest position intermediate the upper and lower extent of said groove wherein the second circumferential apex circumferentially engages said first canted surfaces intermediate the axial extent thereof, said slip being translatable axially in said groove between the upper and lower extent thereof and rockable about said second circumferential apex, between a first condition wherein the slip is relatively retracted and said first and second generally cylindrically curved surfaces are in coextensive engagement and a second condition wherein the slip is relatively extended and said first and second canted surfaces are in surface to surface engagement.

2. The combination of claim **1** wherein in said rest position the axial extent of said slip approximates 80 percent of the axial extent of said groove, the angular disparity between said first and second canted surfaces is approximately 2 degrees, said slip circumferential inclined

plane makes an approximately 15 degree angle with the longitudinal axis of said bore and said sharp circumferential ridge is defined by the juncture of means defining the upper surface of said slip and the trailing edge of said circumferential inclined plane, said upper surface also intersecting the second cylindrically curved surface at the upper extent thereof and defining an uppermost limit stop on said slip.

3. The combination of claim 1 wherein said slip comprises an annular ring and wherein said groove is annular.

4. The combination of claim 1 wherein said slip comprises a spiral having a plurality of turns and said groove comprises a spiral having a plurality of turns, said second part being thereby constructed and arranged to be rotatably withdrawable from said bore of the first part.

5. The combination of claim 4 further including means defining a generally axially directed channel in said one part opening toward said other part, said channel intersecting and incompletely broaching said slip spiral turns; and a strap received in said channel, said strap being sesured to said one part overlying said slip spiral turns; said strap being insufficiently thick to protrude as far as said slip toward said other part.

6. The combination of claim 1 wherein said one part is said second part and wherein said other part is said first part.

7. The combination of claim 6, the first part comprises a sub-sea mounted first tubular fluid confining element and wherein said second part comprises a second tubular fluid confining element lowerable from the sea surface for tying back into said first tubular fluid confining element.

8. The combination of claim 7 further including circumferential sealing means defined on the sub sea fluid confining element within said bore and circumferential sealing means defined on the second fluid confining element positioned for sealing engagement with the first-mentioned sealing means; and a stop shoulder formed on said second fluid confining element for engagement with the sub sea fluid confining element engageable to limit advancement of said second fluid confining element into said bore and to prevent overrunning of said seal.

9. The combination of claim 8 wherein the stop shoulder comprises an exterior, annular circumferential flange on said second fluid confining element arranged to engage the upper end of the sub-sea fluid confining element; and wherein the sealing means comprise complementarily tapered frusto-conical surfaces and resilient sealing material received between the last-mentioned surfaces.

10. A stab-in-tie-back sub for reestablishing communication with the cylindrical bore of a sub-sea well conduit comprising: a tubular fluid confining element; means defining at least one circumferential groove in the exterior of said element and opening radially outwardly thereof; a unitary circumferentially extending slip received in said groove and protruding radially outwardly therefrom, said slip extending at least about halfway around said element; means defining a circumferential inclined plane on said slip facing axially downwardly and radially outwardly at a relatively small acute angle to the longitudinal axis of said element; means defining a sharp circumferential ridge on said slip at the trailing edge of said circumferential inclined plane; and camming means between said groove and said slip responsive to incipient axial withdrawal of said tie-back sub once stabbed-in, for moving said ridge into gouging engagement with the sub-sea well conduit bore; said groove being axially wider than said slip and the camming means comprising: means defining a first canted circumferential surface on said element within said groove, said first canted surface facing radially outwardly and axially upwardly of said element, and means defining a second canted surface on said slip facing radially inwardly and axially downwardly of said element; second canted surface being engageable with and slidable along said first canted surface; said second canted surface being canted slightly more than the first canted surface with respect to the longitudinal axis of said element; and further including means defining a first generally cylindrically curved surface on said element within said groove extending generally parallel to said longitudinal axis, axially upwardly from a first line intersection with said first canted surface, said first line intersection defining a first circumferential apex; and means defining a second generally cylindrically curved surface on said slip extending generally parallel to said longitudinal axis axially upwardly from a second line intersection with said second canted surface, said second line intersection defining a second circumferential apex; said first and second generally cylindrically curved surfaces being of approximately equal axial length; said slip having a rest position intermediate the upper and lower axial extent of said groove wherein the second circumferential apex circumferentially engages said first canted surfaces intermediate the axial extent thereof, said slip being translatable axially in said groove between the upper and lower extent thereof and rockable about said second circumferential apex, between a first condition wherein the slip is relatively retracted and said first and second generally cylindrically curved surfaces are in coextensive engagement and a second condition wherein the slip is relatively extended and said first and second canted surfaces are in surface to surface engagement.

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CARL W. TOMLIN, *Primary Examiner.*

R. G. BERKLEY, *Assistant Examiner.*