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Wetzel

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[54] **METHOD AND APPARATUS FOR RE-POSITIONING THE END OF REMEDIAL TUBING ON AN OBSTRUCTION IN A SUBTERRANEAN WELL**

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[51] **Int. Cl.²** **E21B 23/00;** E21B 43/00

[58] **Field of Search** 166/315, 77, 78, 117.5, 166/301, 277, 240, 250, 98, 99, 178; 175/4.51

[56] **References Cited**

UNITED STATES PATENTS

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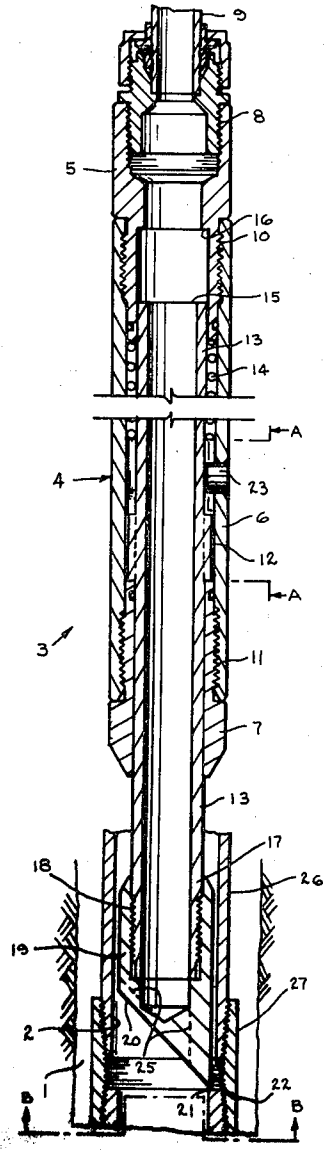
[57] **ABSTRACT**

A method of and apparatus for re-positioning the guided end of remedial coiled tubing for by-passing an obstruction in a subterranean well whereby camming means within the apparatus produce rotary motion in response to longitudinal motion.

19 Claims, 3 Drawing Figures



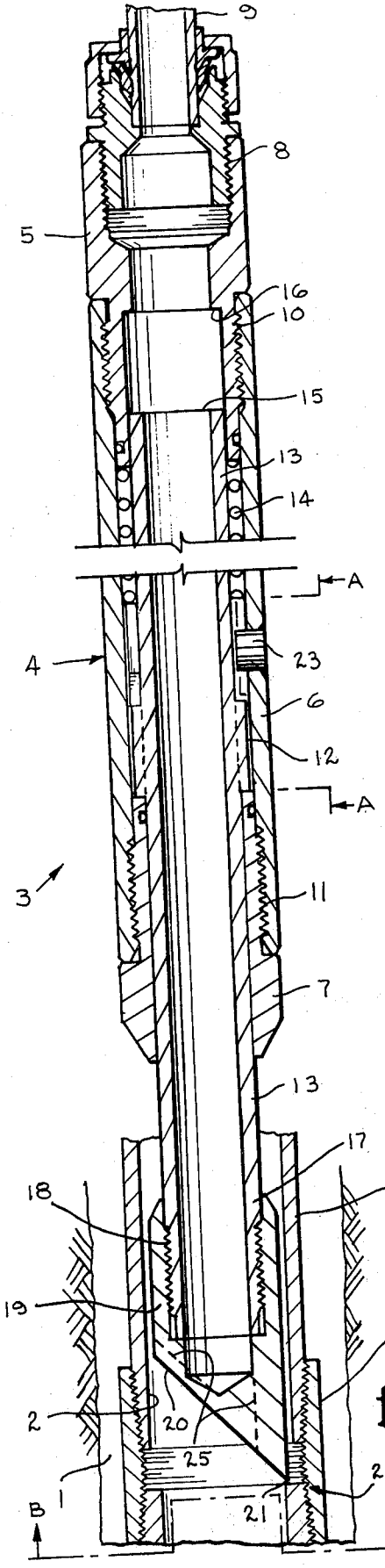


fig.1

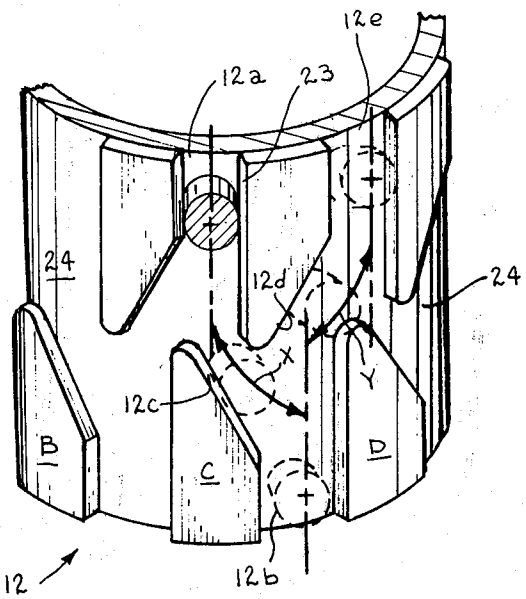


fig.2

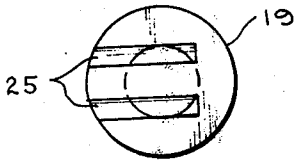


fig.3

METHOD AND APPARATUS FOR RE-POSITIONING THE END OF REMEDIAL TUBING ON AN OBSTRUCTION IN A SUBTERRANEAN WELL

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

The present invention relates to the use of remedial coiled tubing within subterranean oil or gas well production tubing for the purpose of pumping therein fluids for well remedial, production and completion operations. More particularly, the invention relates to a method of and apparatus for re-positioning the guided end of remedial coiled tubing in order to by-pass down hole obstructions.

2. DESCRIPTION OF THE PRIOR ART

In the past, those skilled in the art relating to remedial operations associated with the drilling, production, and completion of subterranean oil and gas wells have relied on conventional "snubbing" or hydraulic workover units which utilize threaded or coupled remedial tubing normally inserted through production tubing for use in operations such as perforating, acidizing and fracturing, corrosion control, pressure testing of tubular goods and vessels, cementing, cleanout operations, sand bridge removal, storm valve recovery, insertion of kill strings, wire line tool fishing, and the like.

In recent years, continuous coiled remedial tubing and injectors for use therewith have contributed substantially to conventional remedial tubing operations. For example, coiled tubing, being continuous, can be inserted into the well faster than threaded and coupled tubing which is furnished in relatively short sections that must be screwed together. In addition, it is easier, when required, to pass continuous tubing through stuffing boxes and blow out preventers because its external diameter is consistently the same size and not interrupted periodically by couplings. The coiled remedial tubing normally is made of steel and is commercially available in sizes from inch O.D. through 1.315 inch O.D., but may have a smaller or larger diameter.

Typical of such remedial coiled tubing and injectors are those described in the 1973 *Composite Catalog of Oil Field Equipment and Services*, at page 662, (Gulf Publishing Co., Houston, Tex.), and manufactured by Bowen Tools, Inc., of Houston, Texas. This type of injector apparatus is generally described in U. S. Pat. No. 3,182,877. The apparatus is commercially referred to as the "Bowen Continuous Spring Tubing Injector Unit" and basically comprises a hydraulically powered injector unit which feeds a continuous remedial tubing string from a coiled or "spooled" work string contained on a powered and generally portable reel unit into the well head by means of two opposed, endless, rotating traction members. Such a reel unit is generally described in U. S. Pat. No. 3,614,019. The upper end of the string which remains on the reel is conventionally connected to the hollow shaft of the reel which permits a liquid or a gas to be pumped through the coiled remedial tubing string by means of a swivel connection. The injector and reel are normally mounted on a single transportable skid, a trailer, or, alternatively, may be componently arranged on skids to facilitate convenient offshore use.

To inject remedial coiled tubing, the injector is arranged on or above the well head. The reel unit, containing up to approximately 15,000 feet of continuous coiled metal remedial tubing, is located preferably about 15 to 20 feet from the well head. The remedial coiled tubing is brought from the reel in a smooth arc loop through the injector unit and into the well through pressure retention and control equipment.

Although the present invention has been primarily conceived for utilization with the injector and remedial coiled tubing as described above, it should be understood that the apparatus and method disclosed and claimed herein are not to be limited to use with this injector and tubing in view of the fact that the particular remedial tubing injector unit or system does not comprise a part of the present invention. Any injector and/or remedial coiled tubing which is compatible with the positioning apparatus described herein may be utilized.

When down hole obstructions, such as mismatched production tubing connections, fittings such as sliding sleeve valves, side pocket mandrels, or the like, interfere with operations which utilize conventional threaded or coupled tubing, rotation of the tubing normally will cause the end of the tubing to slip off the obstruction. However, this remedy is not successfully applicable when coiled tubing is used because the tubing cannot be rotated. Those skilled in the art have relied upon the method of attaching a partial cone-shaped end to the lowered end of the coiled tubing to permit the tubing to slide off an obstruction. Frequently a continual "hang up" will occur because of the inability of the partial cone-shaped end to slide off the obstruction. When this occurs, the coiled tubing is pulled out and the partial cone-shaped end or the end of the tubing, if the cone-shaped end has not been attached to the tubing, cut off at about a 45° angle, or the like, to form a "mule shoe". If the angle of the cut corresponds to the direction and position of the obstruction, the coiled tubing will slide off the obstruction when the tubing is re-inserted in the hole. In the event that the end has not been cut at the correct angle, the "hang up" will continue, and the tubing again must be pulled and the end re-cut. This procedure is continued until the cone end is cut in such a manner that the tubing end eventually will slide off and by-pass the obstruction. However, second and subsequent obstructions may entail a continuation of this procedure. It would be highly desirable, therefore, to provide and utilize a method and apparatus for re-positioning the coiled tubing end in such a manner that the time consuming steps of tubing withdrawal, end cutting and tubing re-insertion could be entirely eliminated.

It is, therefore, an object of the present invention to provide an apparatus for re-positioning the guide end of coiled tubing for by-passing an obstruction in a subterranean well.

It is a further object of the present invention to provide a method for re-positioning the guide end of coiled tubing for by-passing an obstruction in a subterranean well.

Other objects and advantages of the present invention will be readily apparent from a reading of the FIGS., the specification below, and the claims.

SUMMARY OF THE INVENTION

The invention provides a method of and apparatus for repositioning the end of the remedial coiled tubing for by-passing an obstruction in a subterranean well. The apparatus basically is comprised of two moving elements; a tubular outer housing and a mandrel having

a beveled guide end. The mandrel and outer tubular housing are assembled with limited longitudinal telescopic engagement and are urged into extended position by a compressed spring. The camming means within the apparatus produces rotary motion in response to longitudinal motion and comprises a control slot means and a pin for travel therein. The tubular outer housing has the pin attached to it for travel within control slot means circularly affixed to the mandrel. As the end of the apparatus encounters an obstruction, the lower travel of the mandrel is stopped, while the outer housing continues downwardly and compresses a spring. The pin then is caused to travel within the control slot means resulting in the guide end on the mandrel being rotated. The tubing is raised slightly, causing the pin again to travel in the control slot means as the outer housing in response to the spring force moves upward in relation to the mandrel so that the end of the apparatus is further rotated. This series of steps should allow the guide end and the apparatus to slide off and by-pass the obstruction. The steps are repeated if the obstruction continues to prevent downward free travel of the tubing.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a longitudinal drawing of the apparatus in an extended position as run into the well.

FIG. **2** is a perspective view of the control slot means of the apparatus of FIG. **1.**

FIG. **3** is an end view B—B of FIG. **1** showing exits **25** in mule shoe **19.**

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. **1,** showing the preferred apparatus in a well bore hole **1** having production tubing wall **2,** the positioner **3** has tubular outer housing **4** which is comprised of a top sub **5,** connector **6** and bottom sub **7.** Top sub **5** is attached at threads **8** to the end of coiled tubing **9.** Connector **6** is attached to top sub **5** at threads **10** and to a bottom sub **7** at threads **11.** Within connector **6** is pin **23** which projects radially into control slot **12** located within positioner **3** along line A and shown in detail in FIG. **2.**

Located within tubular outer housing **4** is control mandrel **13** encircled by compressed spring **14.** Control mandrel **13** has upper end **15** for limiting downward travel of tubular outer housing **4** by contact with shoulder **16.** Control mandrel **13** also has lower end **17** to which is attached by threads **18** mule shoe **19** having angled end **20** and toe point **21.** Mule shoe **19** is shown in FIG. **1** as "hung" on obstruction **22** which is slightly mismatched connection **27** of production tubing **26.** Control mandrel **13** is tubular to permit passage of fluid which, during remedial operations, is pumped through the tubing and exits the apparatus through exit **25** in mule shoe **19.** Upward travel of tubular outer housing **4** is limited with respect to control mandrel **13** by the contact of lateral projections B, C and D on control slot means **12** with the upper end of bottom sub **7.** The lateral projections B, C and D are spaced from one another in such manner as to provide the different portions **12***a*, 12*b*, 12*c*, 12*d* and **12***e* of the control slot means **12.**

FIG. **2** shows pin **23** along line A projecting radially into control slot means **12.** Pin **23** is affixed to tubular outer housing **4** and projects therein to the control slot means **12.** Control slot means **12** is repetitive in form at angular increments and each portion of the control slot means **12** includes an upper primary slot **12***a*, terminating in a lower secondary slot **12***b* along angular guide surface **12***c*, which, by way of angular guide surface **12***d*, terminates at upper primary slot **12***e*, and so on, completely around control slot means **12.** Cam way **24** is provided within control slot means **12** for travel of pin **23.**

OPERATION OF THE APPARATUS AND METHOD

As remedial coiled tubing end **9** is lowered into bore hole **1** through production tubing **26,** mule shoe **19** may encounter protruding obstruction **22** causing interference with the downward travel of control mandrel **13.** As downward travel of control mandrel **13** terminates, tubular outer housing **4** continues downward travel because coiled tubing end **9** is being lowered. Spring **14** is compressed and pin **23** moves within control slot means **12.**

Assuming that pin **23** initially is in position within control slot means **12** at upper primary slot **12***a*, the downward travel of outer tubular housing **4** in relation to the fixed position of control mandrel **13** will cause pin **23,** which is extended within tubular outer housing **4** to move within cam way **24** along angular guide surface **12***c*. As pin **23** travels in cam way **24** along guide surface **12***c* to lower secondary slot **12***b*, there will be a relative rotation between control mandrel **13** and tubular outer housing **4** which will correspond to angle *x*, which is the angle from the center line of upper primary slot **12***a* and the center line of lower secondary slot **12***b*. Secondary slot **12***b* will retain pin **23** and, in turn, tubular outer housing **4** in a fixed angular position relative to control mandrel **13.** The downward travel of outer housing **4** is limited by the contact of shoulder **16** with mandrel upper end **15.**

Since mule shoe **19** is "hung" on protruding obstruction **22,** and tubular outer housing **4** is retained by the position of pin **23** in lower secondary slot **12***b*, positioner **3** is prevented from further downward travel in bore hole **1.** This will be readily apparent at the well surface by a variation on the weight indicator or similar device.

To fully activate positioner **3,** coiled tubing end **9** is then raised slightly at the well surface. As the tubing end **9** is raised, compressed spring **14** will expand and urge control mandrel **13** and tubular outer housing **4** into their extended position, causing pin **23** to travel in cam way **24** along a path to angular guide surface **12***d*, which will direct pin **23** into upper primary slot **12***e*. As pin **23** travels along angular guide surface **12***d*, control mandrel **13** again moves a distance relative to angle *y*, which is the angle between the center line of lower secondary slot **12***b* and the center line of upper primary slot **12***e*. Upper primary slot **12***e* will retain pin **23** and tubular outer housing **4** in a fixed position.

As the result of the above described steps, angle guide end **20** of mule shoe **19** will be rotated so that it will slide off and by-pass protruding obstruction **22** when coiled tubing end **9** is lowered. In the event that angled guide end **20** still is not in proper position for sliding off and by-passing protruding obstruction **22,** the cycle is repeated by lowering and raising tubing end **9.**

The exact construction of control slot means **12** is not critical to the invention and can vary considerably.

For example, angle *x* and angle *y* may be equal or may vary. In FIG. **2**, angle *x* and angle *y* of control slot **12** are equal and, as an example, each provides a 60° rotation of control mandrel **13**.

Although the invention has been described in terms of specified embodiments which are set forth in detail, it should be understood that this is by illustration only and that the invention is not necessarily limited thereto, since alternative embodiments and operating techniques will become apparent to those skilled in the art in view of the disclosure. Accordingly, modifications are contemplated which can be made without departing from the spirit of the described invention.

I claim:

1. In a subterranean well having a tubular element inserted therethrough and extending to the top of the well, an apparatus for re-positioning the end of tubing for by-passing an obstruction depending from said tubular element comprising:

A. An outer tubular housing connected to said tubing;

B. A control mandrel therein;

C. Camming means for producing rotary motion between the housing and the mandrel in response to longitudinal motion of the tubing; and

D. Guide means on the lower end of the mandrel for by-passing the obstruction.

2. The apparatus of claim **1** additionally comprising a compressed spring encircling said mandrel for extension of the outer tubular housing and the control mandrel.

3. The apparatus of claim **1** wherein the camming means comprises a control slot means and a pin for travel therein.

4. The apparatus of claim **3** wherein the control slot means is affixed to the control mandrel and the pin is affixed to the outer tubular housing.

5. In a subterranean well having a tublar element inserted therethrough and extending to the top of the well, an apparatus for re-positioning the end of tubing for by-passing an obstruction depending from said tubular element comprising:

A. An outer tubular housing connected to said tubing;

B. A control mandrel therein;

C. Camming means for producing rotary motion between the housing and the mandrel in response to longitudinal motion therebetween as a result of first lowering the tubing and contacting the obstruction and thereafter raising said tubing; and

D. Guide means on the lower end of the mandrel for by-passing the obstruction.

6. A method for re-positioning the end of remedial coiled tubing for by-passing an obstruction in a subterranean well, comprising steps of:

A. Lowering in the well said tubing, to the lower end of which is attached an apparatus having:

1. An outer tubular housing;
2. A control mandrel therein;
3. Camming means for producing rotary motion between the housing and the mandrel in response to longitudinal motion of the tubing; and
4. Guide means attached to the lower end of the mandrel for by-passing the obstruction;

B. Activating the apparatus by longitudinally contacting the guide means and the obstruction to prevent lower travel of the mandrel and initiate rotational movement of the camming means;

C. Raising the apparatus to cause additional rotational travel of the camming means; and

D. Lowering the apparatus to permit the guide means to by-pass the obstruction.

7. In a subterranean well having a tubular element inserted therethrough and extending to the top of the well, an apparatus for re-positioning the end of tubing for by-passing an obstruction depending from said tubular element comprising:

A. An upper member connectable to the tubing;

B. A lower member telescopically related to said upper member;

C. Coengageable camming means on said members for producing rotary motion between said members in response to longitudinal movement of the tubing and said upper member relative to said lower member; and

D. Guide means on the lower end of said lower member for by-passing the obstruction.

8. The apparatus of claim **7**; and spring means acting between said members for extending said members with respect to each other.

9. The apparatus of claim **7**; said camming means comprising a control slot in one of said members and a pin on the other of said members adapted to travel relatively in said slot.

10. The apparatus of claim **9**; said control slot being in said lower member, said pin being affixed to said upper member.

11. The apparatus of claim **9**; said control slot having a configuration to produce step-by-step rotary motion of said lower member in response to repeated raising and lowering of said upper member by the tubing.

12. The apparatus of claim **10**; said control slot having a configuration to produce step-by-step rotary motion of said lower member in response to repeated raising and lowering of said upper member by the tubing.

13. The apparatus of claim **12**; said control slot having a configuration to produce step-by-step rotary motion of said lower member in response to repeated raising and lowering of said upper member by the tubing; said guide means having a lower inclined surface to facilitate sliding of said guide means past the obstruction.

14. The apparatus of claim **7**; said guide means having a lower inclined surface to facilitate sliding of said guide means past the obstruction.

15. A method for repositioning the end of remedial coiled tubing for by-passing an obstruction in a well bore, comprising the steps of:

A. Lowering the tubing in the well with an apparatus attached to its lower end having:

1. An upper member connected to the tubing,
2. A lower member telescopically related to said upper member,
3. Camming means for producing rotary motion between said members in response to longitudinal movement ot the tubing and said upper member relative to said lower member, and
4. Guide means on the lower end of said lower member for by-passing the obstruction;

B. Activating the apparatus by longitudinally contacting the guide means and the obstruction to prevent lower travel of the lower member and initiate rotation of the lower member by the camming means;

C. Raising the apparatus to produce additional rotation by the camming means of the lower member and guide means thereon relative to the upper member; and

D. Lowering the apparatus to permit the guide means to by-pass the obstruction.

16. In a subterranean well having a tubular element inserted therethrough, an apparatus for re-positioning the end of tubing for by-passing an obstruction depending from said tubular element comprising:

A. An outer tubular housing connected to said tubing;

B. A control mandrel therein;

C. Means for producing rotary motion between the housing and the mandrel in response to longitudinal motion of the tubing; and

D. Means on the lower end of the mandrel for by-passing the obstruction.

17. In a subterranean well having a tubular element inserted therethrough, an apparatus for re-positioning the end of tubing for by-passing an obstruction depending from said tubular element comprising:

A. An upper member connectable to the tubing;

B. A lower member telescopically related to said upper member;

C. Coengageable means on said members for producing rotary motion between said members in response to longitudinal movement of the tubing and said upper member relative to said lower member; and

D. Means on the lower end of said lower member for bypassing the obstruction.

18. A method for re-positioning the end of tubing for by-passing an obstruction in a subterranean well, comprising the steps of:

A. Lowering in the well said tubing, to the lower end of which is attached an apparatus having: (1) an outer tubular housing; (2) a control mandrel therein; (3) means for producing rotary motion between the housing and the mandrel in response to longitudinal motion of the tubing; and (4) means attached to the lower end of the mandrel for by-passing the obstruction;

B. Activating the apparatus by longitudinally contacting the means attached to the lower end of the mandrel and the obstruction to prevent lower travel of the mandrel and initiate rotational movement of the means for producing rotary motion;

C. Raising the apparatus to cause additional rotational travel of the means for producing rotary motion; and

D. Lowering the apparatus to permit the means attached to the lower end of the mandrel to by-pass the obstruction.

19. A method for re-positioning the end of tubing for by-passing an obstruction in a well bore, comprising the steps of:

A. Lowering the tubing in the well with an apparatus attached to its lower end having: (1) an upper member connected to the tubing; (2) a lower member telescopically related to said upper member; (3) means for producing rotary motion between said members in response to longitudinal movement of the tubing and said upper member relative to said lower member; and (4) means on the lower end of said lower member for by-passing the obstruction;

B. Activating the apparatus by longitudinally contacting the means on the lower end of said lower member and the obstruction to prevent lower travel of the lower member and initiate rotation of the lower member by the means for producing rotary motion between said members;

C. Raising the apparatus to produce additional rotation by the means for producing rotary motion between said members of the lower member and means on the lower end of said lower member relative to the upper member; and

D. Lowering the apparatus to permit the means on the lower end of said lower member to by-pass the obstruction.

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