INDEXING FOR COILED TUBING DRILLING RIG

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Abstract

The invention provides a coiled tube drilling rig (1) for drilling boreholes. The rig includes a drum (2) mounted about a longitudinal axis (B-B) and adapted for receiving a length of semi-rigid tubing (4) wound onto the drum. An injector unit (10) is provided for deploying the tubing (4) along a tubing deployment axis (A-A) and into a borehole, the deployment axis (A-A) being generally orthogonal to and intersecting the drum rotation axis (B-B). An indexing guide (11), confines the tubing in a indexing zone, between a moveable tangential separation point (14) on the drum and the deployment axis (A-A), to a deployment plane (X). The plane being defined by the location of the deployment axis and the separation point (14). The drum is configured to pivot with respect to the deployment plane around an axis (C-C) substantially colinear with said deployment axis (A-A).
INDEXING FOR COILED TUBING DRILLING RIG

FIELD OF THE INVENTION

[0001] This invention relates to a coiled tubing drilling system and has been devised for drilling boreholes in an underground location.

[0002] While the invention has been developed for use drilling substantially horizontal boreholes in restricted spaced environments such as underground mines, it will be appreciated that the invention could also be used in other locations and for drilling other types of boreholes.

BACKGROUND OF THE INVENTION

[0003] The following discussion of the prior art is provided as technical background, to enable the features and benefits of the invention to be fully appreciated in an appropriate technical context. However, any reference to the prior art should not be taken as an express or implied admission that such art is widely known or forms part of common general knowledge in the field.

[0004] There are many instances where it is required to drill horizontal boreholes from an underground drilling rig into a substantially horizontal seam in a mining operation. Such examples include, but are not limited to, the taking of geological samples from underground seams, and gas drainage, e.g. the draining of methane from underground coal seams. These techniques are commonly referred to as “in-seam drilling”.

[0005] In-seam drilling is a significant cost component of underground mining, and in particular coal mining, with a high cost of setting up an in-seam drilling rig and high risk associated with the use of a down hole drilling motor and survey tool system.

[0006] Present drilling rigs typically use conventional drill strings with jointed components which is very labour intensive with manual handling of drill pipe and water connections typically required for every three metres drilled. The normal operational crew of existing in-seam drilling systems is typically three people per shift and there are significant risk and cost benefits to be gained by reducing the general underground population and simplifying the drilling rig used in this situation.

[0007] For surface drilling applications, jointed component drilling has in some cases been replaced by the use of coiled tubing wherein a relatively thin walled strip of sheet metal is coiled and edge-welded into a continuous tube which is able to transmit a longitudinal thrust force while being flexible enough to be wound onto a drum or passed around a bend. The continuous roll of tubing allows for rapid insertion and retraction of down hole tools, and enables these operations to be completed without the need for a conventional work over rig.

[0008] Steering is accomplished by providing an offset drilling mechanism such that the drill will tend to proceed on a curved trajectory. To straighten the drill head, it is necessary to slowly rotate the semi-rigid tubing about its longitudinal axis such that the net cutting effect of the offset cutting head is substantially straight. Since the drill head and tubing are fixedly connected, the entire assembly including the injector mechanism and drum must be rotatable about the longitudinal axis of the tubing deployed in the borehole.

[0009] A particular problem with the use of coiled tube drilling in underground applications is the difficulty in rotating the drum in an environment where space is limited. One solution may be to configure the deployment path of the tubing so that it extends in the plane of and generally radial to the longitudinal axis of the drum rather than along a continuing tangent from the drum. This allows the drum to be rotated about a centralised, rather than a peripheral axis, thereby approximately halving the space require to rotate the drum.

[0010] However, this configuration requires the tubing to follow a less direct path from the drum to the borehole particularly if separation between the drum and borehole entrance is minimised. One major problem is that while the tubing is generally flexible, excessive bending of the tubing can drastically reduce its service life.

[0011] Another issue relates to the manner in which the tubing is wound onto the drum. If the tubing is haphazardly wound onto the drum in a random manner, the storage capacity of the drum is likely to be under-utilised. In addition, haphazard winding of the tubing can result in jamming during winding/unwinding and furthermore, strain concentrations in the tubing, which may, if repetitively applied, result in areas of reduced service life. For this reason it is desirable to carefully control the pattern of the tubing wound onto the drum. This may be achieved by “indexing” the tube in generally parallel contiguous windings on the drum. However, owing to the requirement for compact design, traditional indexing systems are generally unsuitable.

[0012] It is an object of the present invention to overcome or ameliorate at least one of the disadvantages of the prior art, or to provide a useful alternative.

SUMMARY OF THE INVENTION

[0013] In a first aspect, the invention provides, a coiled tube drilling rig for drilling boreholes, the rig including:

[0014] a drum including a drum core, the drum being rotatably mounted about a longitudinal drum rotation axis and adapted for receiving a length of semi-rigid tubing wound onto the drum; and

[0015] a deployment assembly including:

[0016] an injector unit for deploying the tubing along a tubing deployment axis and into a borehole, the deployment axis being generally orthogonal to and generally intersecting the drum rotation axis, and

[0017] an indexing guide for confining the tubing in an indexing zone between a tangential tubing separation point on the drum and the deployment axis, to a deployment plane defined by the tubing separation point and the deployment axis;

[0018] wherein the drum is configured to pivot with respect to the deployment plane around an indexing axis, the indexing axis substantially collinear with the deployment axis, to accommodate movement of the separation point with respect to the drum as a consequence of the confining of the tubing in the indexing zone.

[0019] Preferably, the deployment plane and indexing guide are angularly fixed with respect to the injector unit about the deployment axis.

[0020] Preferably, the rig includes indexing control means for controlling the relative pivoting of the drum thereby controlling the lateral position of separation point such that the tubing is wound onto the drum in a predetermined indexing pattern.

[0021] Preferably, the deployment plane and indexing guide are angularly fixed with respect to the injector unit about the deployment axis.
Preferably, the indexed winding pattern includes contiguous parallel windings.

Preferably, the rig includes an actuator for selectively pivoting the drum relative to the deployment plane.

Preferably, the deployment assembly includes a deployment assembly housing for housing the injector unit and indexing guide.

Preferably, the drum is mounted in a drum frame and the drum frame is pivotally mounted to the deployment housing.

Preferably, the rig includes a support cradle for supporting the drum frame and deployment assembly housing.

Preferably, the actuator is a linear actuator connected between the drum frame and the housing for selectively pivoting the drum relative to the deployment plane.

Preferably, the injector unit comprises a tractor unit providing an axial thrust force to the tubing, for selectively pushing the tubing into the borehole during drilling or retracting the tubing from the hole.

Preferably, the drum and the deployment assembly are rotatably mounted about an axis substantially colinear with the deployment axis.

Preferably, the rig is adapted for receiving a drilling assembly mounted on the end of the semi-rigid tubing and incorporating an offset feature, causing the drilling assembly to deviate from a straight path as the semi-rigid tubing is advanced by the injector unit during drilling operations.

The rig includes a conventional down hole motor.

Preferably, the down hole motor is arranged to drive a PCD drill bit and the drilling assembly also includes a survey and geo-sensing package.

Preferably, the offset feature comprises a bent-sub housing arranged such that the axis of the drill bit is offset from the longitudinal axis of the coiled tubing in the borehole.

Preferably, the semi-rigid tubing is deployed into the borehole through a peripheral seal, allowing borehole fluid to be constantly pressurized during drilling operations.

According to a second aspect, the invention provides a drilling rig for drilling boreholes, the rig including:

- a drum mounted in a drum frame and arranged for selectively receiving a length of semi-rigid tubing wound onto a drum core of the drum, the drum being rotatably mounted in the frame about a longitudinal drum rotation axis to facilitate winding of the tubing;
- a deployment assembly for deploying the tubing into a borehole along a tubing deployment axis, the axis being substantially orthogonal to and extending radially from the drum rotation axis, wherein the deployment assembly includes:
  - an injector unit for providing an axial force to the tubing along the tubing deployment axis;
  - an indexing guide for confining the tubing in an indexing zone between a tangential tubing separation point on the drum and the deployment axis, to a tubing deployment plane being generally coincident with and parallel to the deployment axis; and
- a deployment assembly housing, for housing the injector unit and indexing guide;
- a drilling assembly mounted on the end of the semi-rigid tubing and incorporating an offset feature causing the drilling assembly to deviate from a straight path as the semi-rigid tubing is advanced by the injector unit during drilling operations;
- a support cradle for supporting the drum frame and deployment assembly;
- the drum frame and the housing being rotatably mounted to the cradle about an axis substantially coincident with the deployment axis; and
- wherein the drum is configured to pivot with respect to the deployment plane around an indexing axis, the indexing axis substantially collinear with the deployment axis, to accommodate movement of the separation point with respect to the drum as a consequence of the confining of the tubing in the indexing zone.

According to another aspect, the invention provides a method of indexing tubing in a coiled tube drilling rig for drilling boreholes, the method including the steps of:

- providing a drum for receiving a length of semi-rigid tubing wound onto a drum core of the drum between a pair of end stops, wherein the drum is rotatably mounted about a longitudinal drum rotation axis;
- deploying and retracting the tubing along a tubing deployment axis into a borehole from and to the drum respectively, the deployment axis being generally orthogonal to and intersecting the drum rotation axis; and
- confining the tubing in an indexing zone between a tangential tubing separation point on the drum and the deployment axis, to a deployment plane defined by the tubing separation point and the deployment axis;
- pivoting the drum around an axis substantially collinear with the deployment axis to accommodate movement of the separation point with respect to the drum as a consequence of the confining of the tubing in the indexing zone.

Preferably, the method includes controlling the relative pivoting of the drum to selectively position the separation point between the end stops to facilitate a predetermined indexing pattern.

Preferably, the indexed winding pattern includes contiguous parallel windings.

Preferably, the tubing is deployed and retracted by an injector unit for providing an axial thrust force to the tubing, for selectively pushing the tubing into the borehole during drilling or retracting the tubing from the hole.

Preferably, the tubing is confined to the deployment plane by an indexing guide.

Preferably, the drum, the injector unit and the indexing guide are rotatably mounted about an axis substantially collinear with the deployment axis.

Although the invention has been described with reference to specific preferred examples, it will be appreciated by those skilled in that art that it may be embodied in many other forms. In particular, features of any one of the various described preferments may be provided in any combination in any of the other described preferments.

BRIEF DESCRIPTION OF THE DRAWINGS

Notwithstanding any other forms that may fall within its scope, one preferred form of the invention will now be described by way of example only with reference to the accompanying drawings in which:

FIG. 1 is a perspective view of a coiled tube-drilling (CTD) rig according to the invention;

FIG. 2 is a schematic side view of a CTD rig in accordance with the invention;

FIG. 3A is a schematic end view of a CTD rig in accordance with the invention;
FIG. 3B is a schematic end view of a CTD rig in accordance with the invention;

FIG. 3C is a schematic end view of a CTD rig in accordance with the invention;

FIG. 4 is an end view of the rig shown in FIG. 1;

FIG. 5 is an end view of the rig shown in FIG. 4, as more tube is wound onto the drum, and the drum and deployment assembly are rotated around the deployment axis; and

FIG. 6 is an end view of the rig shown in FIG. 4, as more tube is wound onto the drum, and the drum and deployment assembly are rotated around the deployment axis.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

The CTD (coiled tubing drilling) system according to the invention is a compact, highly mobile drilling device for deployment within an underground mining situation which might typically include a mine road having a floor located adjacent to a seam where it is desired to drill a substantially horizontal borehole.

The device includes a drum having a drum core onto which the tubing is wound between opposing end stops, shown as flanges 5 and 6. The device also includes a deployment assembly for deploying or retracting the tubing. The device includes a linear tubing deployment axis A-A along which the tubing is deployed. In practice, the deployment axis A-A defines the initial borehole centreline.

The drum is mounted within a drum frame attached to the deployment assembly. A drum rotation motor (not shown) rotates the drum around its longitudinal axis B-B to feed tubing on and off the drum.

The tubing is neatly wound onto the drum in indexed windings, rather than being haphazardly wound in a random manner. Generally, the indexed winding is made parallel and contiguous as shown by the tube 4a, 4b, 4c etc. There may be several layers of indexed windings on the drum depending on the drum capacity, flange height and tubing diameter.

The deployment assembly includes an injector (tractor) unit 10, a tubing-indexing guide 11 and a tube straightener 12. The injector unit 10 provides an axial thrust force to the tubing along the linear deployment axis A-A, thereby pushing the tubing and an attached downhole assembly (not shown) into the borehole during drilling. The injector unit 10 is also capable of applying a reversed axial force to the tubing in order to retract the tubing and downhole assembly from the hole as required.

While the tubing is resilient, it may plastically deform as it is wound on to and stored on the drum and/or passed along the guide means. The tube straightener 12 includes straightening rollers 12a, 12b and 12c which straighten the tubing before it passes into the injector unit. These straightening rollers each include a central guide groove to laterally locate the tubing.

Owing to the stress required to both elastically and plastically deform the tubing, it will be appreciated that the drum rotation motor (not shown) provides sufficient torque to the drum to maintain tension in the tube on the drum and between the drum and the injector unit, particularly during winding. During deployment, the rotation of the drum must also be carefully controlled so that the tubing, having considerable spring potential energy, does not inadvertently unravel. In this embodiment, the motor acts as braking means however in alternative embodiments a separate mechanical braking or ratcheting system may be used in place of or in addition to the motor.

Referring to FIG. 2, the injector unit and tubing guide define a curved tubing deployment path, marked by centreline 13, along which the tubing passes as it is deployed from the drum and into the borehole. The path 13 is bounded at one end by a tangential tubing separation point 14 where the tubing separates from the drum and at the other end by a tubing outlet 15 located on the linear deployment axis A-A. The path 13 is comprised of two portions: a generally straight zone 16 passing through the injector unit and the straightener 12; and a curved indexing zone 17 between the tangential tubing separation point 14 on the drum 2 and the deployment axis (A-A).

The straight portion 16 of the deployment path 13 is generally fixed so that once drilling is initiated, the tubing exiting the device remains coincident with the borehole centreline. Accordingly, the injection unit not only provides an axial thrust to deploy and retract the tubing, but also provides a lateral constraint to stabilise the tubing on the axial deployment path.

Since the indexing zone 17 of path 13 is relatively tightly curved, the tubing undergoes relatively high strain as it passes through this section between the drum and injector unit 10. In this embodiment the indexing guide 11 includes an array of rollers 19 to restrain and maintain the tubing on the deployment path. Like the straightening rollers 12, each roller 19 includes a circumferential guide groove to securely locate the tube and reduce lateral deviation.

The position of the tangential separation point 14 at the drum end of the indexing zone 17 of the deployment path 13 is not fixed and moves back and forward between the drum end flanges 5 and 6 as tubing is wound onto or from the drum. During tubing deployment, the movement of the separation point 14 is determined by the manner in which the tubing was previously wound onto the drum. The indexing guide 11 follows the separation point 14 as it moves and delivers the tubing to the injector unit. However, during tubing retraction, as the tubing is wound onto the drum, the indexing guide 11, as its name suggests, performs an important role indexing the tubing by actively directing the path of the tubing to a moveable predetermined separation point in accordance with a predetermined winding pattern.

It is a feature of the invention that it provides an indexing system wherein the indexing guide is generally laterally fixed and the drum is movable. More specifically, the indexing guide 11 is fixed angularly with respect to the deployment axis thereby fixing the tubing deployment path on a deployment plane. This plane which is fixed relative to the deployment assembly, is shown in broken outline in FIG. 1 and as a line in FIGS. 3A, 3B, 3C, 4, 5 and 6, and is marked as X. In one frame of reference, the deployment plane X is generally defined by the location of the separation point and the deployment axis A-A. However, the deployment plane X is generally fixed with respect to the deployment assembly and since the drum is movable relative to the deployment plane X, the separation point 14 effectively can be selectively moved back and forth between the drum end flanges 5 and 6 as tubing is wound on to the drum such that the winding pattern can be controlled.

In this embodiment, movement of the drum is provided by a pivot axis generally coincident with the deployment axis A-A. Referring to FIG. 1, the drum is pivotable
about indexing axis C-C by means of a ring bearing 21 between the drum frame and the deployment assembly. A linear actuator 22 is tangentially disposed between the drum frame 9 and deployment assembly to provide a pivot force to pivot the drum frame with respect to the assembly.

[0078] The FIGS. 3A, 3B and 3C show a cross-sectional schematic front view of the device as tubing is wound on to the drum. The drum 2 is rotationally mounted about axis B-B to wind tubing onto and off the drum. The tubing deployment axis A-A and drum indexing axis C-C are coincident and normal to the page. The deployment plane is also shown end-on, and is represented by broken line X. In this embodiment, the deployment plane X, deployment axis A-A and indexing axis C-C pass through the midpoint of the drum’s longitudinal axis at 23. In the figures, the tubing being immediately wound onto or deployed from the drum has been shaded and is marked as reference number 24. Given the end-on orientation of the schematic diagram, the tubing 24 does not correspond to the separation point 14, which is shown. Depending on the winding pattern used, and the position in the winding pattern, the separation point 14 and tubing 24 may not be aligned as shown. The tubing windings stored on the drum are un-shaded.

[0079] In FIG. 3A, it can be seen that the tubing separation point 14 is midway between the end flanges 5, 6 on the drum 2. In this central configuration, the drum rotation axis B-B is normal to the deployment plane X and perpendicular to the deployment axis A-A.

[0080] As more tubing is wound onto the drum, the separation point 14 must be shifted to maintain the ordered, contiguous winding pattern on the drum. FIG. 3B shows the drum has been pivoted about indexing axis C-C in a clock-wise direction from the central position shown in FIG. 3A so that the separation point is positioned as required for the next winding coil. It will be noted that the separation position remains on the deployment plane X.

[0081] As still more tubing is wound onto the drum, it must be pivoted to match. This is shown in FIG. 3C, where the drum has been pivoted to the left in an anti clock-wise direction from the central position shown in FIG. 3A. This maintains the required separation point 14 so that the tubing is forced into the winding pattern. Again, it will be seen that the drum is pivoted and the deployment plane and separation point remain fixed.

[0082] It will be appreciated, with reference to the drawings and the above description, that as the drum is rotated away from its central position, as shown in FIG. 3A, the indexing guide will be subjected to lateral side forces from the tubing. However, as explained above, the indexing guide includes circumferential locating grooves to resist lateral movement. Additional lateral rollers or guides not shown in the figures may also be used to resist lateral forces of the tubing. These lateral rollers are mounted for rotation about axes generally orthogonal to those of the guide rollers 19, shown in FIG. 2.

[0083] In addition, comparing FIGS. 3A, 3B and 3C, it is apparent that the radial distance from the deployment axis to the separation point varies, as shown by arrow 25. This is caused by the change in angular orientation of the pivoting drum and/or the number of tubing layers stored on the drum. In this regard, the indexing guide must be able to account for the variable radial distance. As such the guide is provided with some vertical compliance so that the rollers 19 can compensate.

[0084] When winding tubing on the drum, the system must predict the required position of the separation point to maintain the indexing pattern. To do so, an indexing control system (not shown) measures one or more parameters to determine the instantaneous required separation point. In a simple form, this may include measuring the tubing payout which combined with the tubing thickness and drum dimension can be used by dead-reckoning to calculate a separation position map. Alternatively, more sophisticated methods may be used including the use of one or more sensors to measure the location of the tubing on the drum, the width of the tubing, the drum boundaries etc. A control unit responds to the sensors predicting the required separation point. In this regard the more sophisticated system may account for tubing stretching and flattening which may not be resolved in a simple indexing system.

[0085] As discussed above, in order to provide directional control of the down hole drilling assembly, the tubing must be rotated about its longitudinal axis. Accordingly, the drum, drum frame and deployment assembly are all configured to rotate about the deployment axis A-A which is coincident with the initial borehole centreline.

[0086] In this embodiment, the deployment assembly includes a cage 26 within which the indexing guide 11 and injector unit 10 are mounted. The drum frame is mounted on the cage by means of ring bearing 221. The cage includes fore and aft mounting rings, 27 and 28 which rest on respective pairs of rollers 29 and 30 on a support cradle 31. An hydraulic and power swivel 32 shown in FIG. 1 transfers hydraulic fluid, drilling fluid and electrical power from the stationary frame to the rotating frame. In this way the drum and deployment assembly are configured for mutual rotation about the tubing deployment axis A-A. Such rotation causes the tubing to rotate within the borehole, thereby allowing control of the orientation (clock face) of the down hole assembly as is known in the art.

[0087] This can be seen in FIGS. 4, 5 and 6 which display partial end views of the rig at different angles of rotation of the deployment assembly and drum, and as progressively more tubing is wound onto the drum. While the whole system rotates, the pivoting of the drum with respect to the deployment path can be seen by inspecting the relative orientation between the drum rotation axis B-B and the line representing the deployment plane X.

[0088] In this manner the indexing system allows for space efficient tubing storage and distribution system in a relatively compact simple apparatus. The CTD rig is fast and simple to operate using reduced manpower and can be deployed in an underground situation for the cost effective drilling of underground boreholes.

[0089] The coiled tubing drilling indexing system offers further benefits over conventional drilling systems in that it can increase the service life of the tubing by regulating and reducing strain applied during deployment and stowage.

1. A coiled tube drilling rig for drilling boreholes, the rig including:
   a drum including a drum core, said drum being rotatably mounted about a longitudinal drum rotation axis and adapted for receiving a length of semi-rigid tubing wound onto the drum; and
   a deployment assembly including:
   an injector unit for deploying the tubing along a tubing deployment axis and into a borehole, said deployment
axis being generally orthogonal to and generally intersecting the drum rotation axis; and
an indexing guide for confining the tubing in an indexing zone between a tangential tubing separation point on
the drum and the deployment axis, to a deployment plane defined by the tubing separation point and the deployment axis;
wherein the drum is configured to pivot with respect to the deployment plane around an indexing axis, said indexing axis substantially collinear with said deployment axis, to accommodate movement of the separation point with respect to the drum as a consequence of the confining of the tubing in the indexing zone.

2. A drilling rig according to claim 1, wherein the deployment plane and indexing guide are angularly fixed with respect to the injector unit about the deployment axis.

3. A drilling rig according to claim 2, further including indexing control means for controlling the relative pivoting of the drum thereby controlling the lateral position of separation point on the drum such that the tubing is wound onto the drum in a predetermined indexing pattern.

4. A drilling rig according to claim 3, wherein the indexed winding pattern includes contiguous parallel windings.

5. A drilling rig according to claim 4, including an actuator for selectively pivoting the drum relative to the deployment plane.

6. A drilling rig according to claim 1, wherein said deployment assembly includes a deployment assembly housing for housing the injector unit and indexing guide.

7. A drilling rig according to claim 6, wherein said drum is mounted in a drum frame and said drum frame is pivotally mounted to said deployment housing.

8. A drilling rig according to claim 7, further including a support cradle for supporting the drum frame and deployment assembly housing.

9. A drilling rig according to claim 5, wherein said actuator is a linear actuator connected between said drum frame and said housing for selectively pivoting the drum relative to the deployment plane.

10. A drilling rig according to claim 1, wherein the injector unit comprises a tractor unit providing an axial thrust force to the tubing, for selectively pushing the tubing into the borehole during drilling or retracting the tubing from the hole.

11. A drilling rig according to claim 1, wherein said drum and said deployment assembly are rotatably mounted about an axis substantially collinear with the deployment axis.

12. A drilling rig according to claim 1, adapted for receiving a drilling assembly mounted on the end of the semi-rigid tubing and incorporating an offset feature, causing the drilling assembly to deviate from a straight path as the semi-rigid tubing is advanced by the injector unit during drilling operations.

13. A drilling rig according to claim 12, wherein the drilling assembly includes a conventional down hole motor.

14. A drilling rig as claimed in claim 13, wherein the down hole motor is arranged to drive a PCD drill bit and the drilling assembly also includes a survey and geo-sensing package.

15. A drilling rig as claimed in claim 13, wherein the offset feature comprises a bent-sub housing arranged such that the axis of the drill bit is offset from the longitudinal axis of the coiled tubing in the borehole.

16. A drilling rig as claimed in claim 1, wherein the semi-rigid tubing is deployed into the borehole through a peripheral seal, allowing borehole fluid to be constantly pressurised during drilling operations.

17. A drilling rig for drilling boreholes, the rig including:
a drum mounted in a drum frame and arranged for selectively receiving a length of semi-rigid tubing wound onto a drum core of said drum, said drum being rotatably mounted in the frame about a longitudinal drum rotation axis to facilitate winding of the tubing;
a deployment assembly for deploying the tubing into a borehole along a tubing deployment axis, said axis generally orthogonal to and extending radially from the drum rotation axis, wherein said deployment assembly includes:
an injector unit for providing an axial force to the tubing along the tubing deployment axis;
an indexing guide for confining the tubing in an indexing zone between a tangential tubing separation point on the drum and the deployment axis, to a tubing deployment plane being generally coincident with and parallel to the deployment axis; and
a deployment assembly housing, for housing the injector unit and indexing guide;
a drilling assembly mounted on the end of the semi-rigid tubing and incorporating an offset feature causing the drilling assembly to deviate from a straight path as the semi-rigid tubing is advanced by the injector unit during drilling operations;
as support cradle for supporting the drum frame and deployment assembly;
said drum frame and said housing being rotatably mounted to the cradle about an axis substantially coincident with the deployment axis; and
wherein the drum is configured to pivot with respect to the deployment plane around an indexing axis, said indexing axis substantially collinear with said deployment axis, to accommodate movement of the separation point with respect to the drum as a consequence of the confining of the tubing in the indexing zone.

18. A drilling rig according to claim 17, wherein the deployment plane and indexing guide are angularly fixed with respect to the injector unit about the deployment axis.

19. A method of indexing tubing in a coiled tube drilling rig for drilling boreholes, the method including the steps of:
providing a drum for receiving a length of semi-rigid tubing wound onto a drum core of said drum between a pair of end stops, wherein said drum is rotatably mounted about a longitudinal drum rotation axis;
deploying and retracting the tubing along a tubing deployment axis into a borehole from and to the drum respectively, said deployment axis being generally orthogonal to and intersecting the drum rotation axis; and
confining said tubing in an indexing zone between a tangential tubing separation point on said drum and said deployment axis, to a deployment plane defined by the tubing separation point and the deployment axis;
pivoting the drum around an axis substantially collinear with said deployment axis to accommodate movement of the separation point with respect to the drum as a consequence of the confining of the tubing in the indexing zone.
20. A method according to claim 19, further including controlling the relative pivoting of the drum to selectively position the separation point to facilitate a predetermined indexing pattern during winding of the tubing onto the drum.

21. A method according to claim 20, wherein the indexed winding pattern includes contiguous parallel windings.

22. A method according to claim 19, wherein the tubing is deployed and retracted by an injector unit for providing an axial thrust force to the tubing, for selectively pushing the tubing into the borehole during drilling or retracting the tubing from the hole.

23. A method according to claim 20, wherein the tubing is confined to the deployment plane by an indexing guide and wherein the deployment plane and indexing guide are angularly fixed with respect to the injector unit about the deployment axis.

24. A method according to claim 23, wherein said drum, said injector unit and said indexing guide are rotatably mounted about an axis substantially colinear with the deployment axis.

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