ARTICULATED MAST FOR A COILED TUBING RIG

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Filed: Jun. 5, 2007

Foreign Application Priority Data
Jun. 6, 2006 (CA) ........................................ 2549664

Publication Classification

Int. Cl.
E21B 19/22 (2006.01)

U.S. Cl. ....................................................... 166/77.2

ABSTRACT

An articulated mast for use in supporting a coiled tubing injector on a deck of a transport trailer and capable of accomplishing storage of the mast and the injector in a compact manner on the deck for transport on the one hand in conjunction with other equipment in drilling operations, and yet capable of ready deployment of the injector to an operative position above a well head on the other hand. The mast includes boom sections pivotally joined relative to each other for movement between a position in which the sections are folded one on top of the other on the deck to an extended position for holding the tube injector above the well head rear of the transport deck.
ARTICULATED MAST FOR A COILED TUBING RIG

[0001] This invention claims the benefit of convention priority of Canadian Patent Application No. 2,549,664, filed Jun. 6, 2006, entitled Articulated Mast For A Coiled Tubing Rig, the disclosures of which are incorporated herein by reference.

FIELD OF THE INVENTION

[0002] This invention relates to an articulated mast for use in injection of tubing in well drilling operations.

BACKGROUND OF THE INVENTION

[0003] In well drilling and servicing operations utilizing the coiled tubing technique, rigs are usually constructed on a transport trailer which may carry both the reel of continuous tubing and the mast which supports the tubing during injection and withdrawal of the tubing from the well being formed or serviced. In this arrangement while the mast must be capable of supporting the injection unit over the well head, it must be constructed to be lowered to a transport position which allows the trailer to be drawn over not only various forms of terrain, but along public roadways which have, of course, various restrictions, including overhead and width clearances. It is also essential that the mast and the injection unit be capable of quick installation over the well head once on site with the minimum of labour and subsequently restored to a transport condition after the well operation is completed.

SUMMARY OF THE INVENTION

[0004] It is an object of the present invention to provide a coiled tubing injection system which is equipped with a versatile mast system capable of compact storage on a transport trailer but one which can be conveniently and quickly moved between operating and travel modes by way of that trailer. It is particularly an object of the present invention to provide a mast which allows locating of the injector unit accurately over a well head in a quick and efficient manner.

[0005] According to the present invention there is provided an articulated mast for use in locating a tubing injection unit over a well head, and wherein the mast includes a lower mast section pivotally connected at one end to a carrier unit, an upper mast section pivotally connected at one end to a second end of the lower mast section opposite to the one end, and an extendible mast section carried at an end of the upper mast section opposite the one end and having an outer end for supporting the injector tubing injection unit. A first actuator means is connected between the lower mast section and the carrier unit for raising the lower mast section from a lowered transport position disposed substantially horizontally on the deck to a more upright operating position. A second actuator means is connected between the lower mast section and the upper mast section for pivoting the upper mast section independently of the first actuator means from a transport position immediately overlying the lower mast section in the transport position to a raised operating position. A third actuator means operative independently of the first and second actuator means for moving the extendible mast section relative to the upper mast section from a retracted position to a position selectively projecting beyond the outer end of the upper mast section.

[0006] According to another aspect of the invention there is provided an articulated mast supporting a tubing injector unit for use on a transport trailer of the type having a rear deck portion, the articulated mast including, a lower boom or mast section having, a first connection means connecting one end of the lower mast section to the rear deck portion for pivotal movement from a substantially horizontal position on the rear deck about a transverse axis to a raised substantially vertical position, and first actuator means for raising and lowering the lower mast section between the horizontal and raised positions. There is further provided an upper boom or mast section having a main body portion with a second connection means for connecting a first end of the upper mast section to a second end of the lower mast section for pivotal movement of the upper mast section about a transverse axis parallel to the transverse axis of the first connecting means. This achieves raising of the upper mast section from a first horizontal position atop the lower boom section in the horizontal position of the lower mast section to a raised slanted position having upward and rearward components. A second actuator means is provided for raising and lowering the upper mast section between the positions of the upper mast. The upper mast section includes an extendible portion at a second end thereof and connected to the main body portion of the upper mast section for telescopic movement relative thereto so as to provide positioning of the extendible portion between a retracted position and an extended position for thereby increasing total length of the upper mast when in the extended position. A third actuator means is provided for moving the extendible portion between the retracted and extended positions. Connection means is mounted on the extendible portion of the upper mast member for carving a tubing injection unit.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is a side elevational view of a complete coiled tube injection system incorporating the articulated mast of the present invention in a transport mode;

[0008] FIG. 2 is a plan view of the system of FIG. 1;

[0009] FIG. 3 is a rear view on an enlarged scale of the system of FIG. 1;

[0010] FIG. 4 is a side elevational view of the system of FIG. 1 but showing the injector moved to a position to allow the maneuvering of the gooseneck of the injector to an operative position;

[0011] FIG. 5 is a side elevational view showing the initial movement of the lower and upper sections of the mast of the present invention towards an operative position;

[0012] FIG. 6 is a side elevation view showing the final positions of the lower and upper section of the mast relative to each other; and

[0013] FIG. 7 is a side elevational view showing the final extension of the upper section of the mast for placement of the injector over the well head structure.

[0014] FIG. 8 is a simplified rear view of the articulated mast in an extended position, but with the coiled tubing injector removed.
FIG. 9 is a simplified side view for illustrating the positioning of the actuator for the extendible mast section.

FIG. 10 is an enlarged side view illustrating the transverse pivot connection between the lower and upper mast section.

FIG. 11 is an enlarged side view illustrating the pivot connection of a tubing injector unit to the upper end of the mast.

DETAILED DESCRIPTION OF THE INVENTION

As shown in FIGS. 1 and 2, the complete coiled tubing injector system incorporating the articulated mast 10 of the invention is constructed on a carrier unit shown here as a road transport trailer 11 for being pulled between drilling or servicing sites by way of a tractor (not shown) when connected to the trailer through a fifth wheel system.

The transport trailer 11 provides a front deck portion 12 on which are mounted servicing components 12 which may include, for example, components for supplying pressurized hydraulic fluid, such as an electric motor and pump unit, a hydraulic cooler, and a hydraulic tank. The transport trailer 11 further provides a middle, dropped portion 29 in which is mounted the tubing storage reel 14. The articulated mast 10 of the present invention is mounted on a rear deck portion 15 of the transport trailer.

The articulated mast 10 of the present invention includes a first boom or lower mast section 16 connected at a first end to the rearmost part of the rear deck position 15 by way of a transverse pivot connection 17 to allow pivoting of the lower section from a position which is substantially horizontally disposed on the deck (FIGS. 1 & 4) to a more upright position as seen in FIGS. 5 to 7. The lower mast section is provided with motor or actuator means 18 (FIG. 5), which is shown in the form of an expandable hydraulic cylinder pivotally connected at one end to the rear deck position forward of the transverse pivot connection 17, and at the other end to the lower section 16 of the mast section at a point closer to the opposite end or of the lower section 16.

The articulated mast 10 further includes a second boom or upper mast section 20 which is pivotally connected at a first end by a transverse pivot connection 21 to a second or upper end of the lower section 16 for pivotal movement about a transverse axis 21 parallel to the axis of pivotal connection 17. The transverse pivot connection 21 has its axis offset relative to the center lines of the lower and upper sections 16, 20 in order that, as will be described in more detail below, when the articulated mast is in its lower most position as seen in FIGS. 1 and 4, the two sections are juxtaposed and both substantially horizontal and parallel to each other, so as to occupy the minimum of height for transport. On expansion of the hydraulic cylinder 18, the lower boom section is pivoted in a clockwise direction about pivot connection 17 as viewed in FIG. 5. Mounted on the lower section 16 there is disposed second motor or actuator means 22 which is again in the form of an expandable hydraulic cylinder, the piston rod of which is connected through a linkage 23 to the upper section 21. This second cylinder is pivotally connected at a lower end to the lower section 16, and at its piston end to the linkage 19 which is described in more detail below, so that an expansion of the actuator means 22 the upper section is pivoted upwardly and away from the lower section 16 as shown first in FIG. 5, and then to its operative position as shown in FIG. 6.

It may be noted, particularly from FIG. 10, that the second end or upper end of the lower section 16 of the mast forms an offset portion 40 in which the transverse pivot connection 21 for the first or lower end of the upper section 20 is located. Further, it can be seen that the lower end of the upper section 20 forms an offset portion 41 in which the axis of the pivot connection 21 is disposed. The linkage 19 includes a pair of links 42, 43, each of which (42) are pivotally connected on a common axis to the end of the piston rod of the hydraulic cylinder forming the actuator 22. Link 42 is pivotally connected at its other end to the upper end of the lower section 16 of the mast. The one end of the second link 43 is thus connected coxially with the first link 42 to the end of the piston rod, but at its other end, the link 43 is pivotally connected to the lower end portion of the upper section 20 of the mast. With this linkage arrangement 19, the upper section 20 of the mast can be pivoted from its folded position in which it can be brought into parallel or even contacting relation to the lower section 16. However, the upper section 20, on full expansion of the actuator means 22, can be swung at least to a position in which it is aligned (180°) in relation to the lower mast portion. This allows a maximum amount of positioning of the mast when extended, but while in the folded condition permits the positioning of the upper section 20 when brought back to its folded condition to closely overlie the lower section 16, thereby providing a minimum of height for travel.

The second boom or upper mast section 20 includes a third mast portion in the form of an extendible portion 24 (FIGS. 7 & 8) which is contained within the member of the main body of the upper section 20. This extendible portion 24 is in effect telescopically positioned relative to its main body of upper section 20, and is actuated by a third actuator means 45 (FIG. 8) in the form of an expandable hydraulic cylinder, which is within and connected to the main body of the upper section 20 with a piston rod 46 thereof being connected to the extendible portion 24. Thus, on expansion of this third expandible cylinder actuator 45, the extendible portion 24 is forced outward relative to the main body portion of the upper section 20 to effectively extend the length of upper section 20 of the mast 10. The extendible portion 24 is shown in the most projected position in FIGS. 7 & 8.

A tube injector unit 25 is connected to the outer end of the extendible portion 24 in a manner to pivot about a transverse axis 37 parallel to the axis of the pivot connections 17 and 21. The pivot action of the injector unit 25 relative to extendible portion 24 of the mast 10 is provided through a linkage 26, which is connected between the extendible portion 24 and a framework of the injection unit 25, and includes actuator means 27 in the form of a fourth expandible cylinder. On expansion of the actuator means 27, the injector unit 25 is movable from a position in which the main central axis 47 of the injector unit is substantially parallel to the axis of the lower and upper sections (16, 20) of the mast in the transport mode as shown in FIG. 1, eventually to a position wherein its main central axis 47 is essentially vertical as positioned over a well head structure 28 as shown in FIGS. 7 & 10.
[0025] The injector unit 25 is of a common form used in the industry, having the main injection drive portion 30 and a gooseneck 31 which directs the tubing 32 being drawn from the storage reel 14 through a smooth curve. As is more apparent in the enlargement shown in FIG. 11 the linkage 26 is capable of accomplishing the swinging of the injection unit 25 from a horizontal transport position immediately above the upper section 20 and its contained extendible section 24 then retracted to the full vertical operational position (FIGS. 7 & 8) by way of a single actuator means 27 in the form of a double acting hydraulic cylinder. The linkage includes a first link 50 which is attached at an outer end to a pin 51 forming a common first transverse axis at the end of the piston rod 52 of the actuator means 27. An opposite end of the link 50 is pivotally connected to the injector unit 25 by a pin 53 affixed to the injector unit. The injector unit 25 per se is pivotally connected to the outer end of the extendible section 24 by way of a shaft 54 forming the transverse pivot axis of the injector unit 25. Carried by shaft 54 up an arm 55, which is pivotally connected by a pin 56 to one end of link 57 in turn pivotally connected at its opposite end to pin 51. It may be noted that the orientation of the central axis of the injector unit 25, with the actuator 27 in a retracted position, is substantially parallel to the longitudinal axis of the store sections 16 and 20 of the mast 120 and thus providing a low profile and safe stored position of the injector unit 25 of the unit for transport.

[0026] The gooseneck 31 is designed to be collapsed as the articulated mast is contracted to a transport mode so as to conveniently occupy a space provided between spaced side members forming the upper and lower sections 16, 20 of the mast. As shown the gooseneck consists of three sections, which in the operative form are in position to form a smoothly formed track defining the path of travel of the tubing 32. A main portion 33 of the gooseneck is affixed to the framework of the injection drive portion, and an intermediate portion 34 is hinged to an outer end of main portion 33, the latter being provided with a double action hydraulic cylinder 35 which, when expanded, pushes the intermediate portion 34 to its operating position as shown in dashed lines in FIG. 4. An outer end portion 36 is pivotally connected to the free end of the intermediate portion, with a hinge providing a limited swing into a curvature forming position in order that it is free to swing from a relative straight continuation of the intermediate portion in storage, as shown in FIG. 1 to its operative form as shown in FIGS. 5 to 7, the swinging operation being depicted by the two positions illustrated in FIG. 4.

[0027] Following through from the relative positions of the articulated mast as shown in FIG. 1 and FIGS. 4 to 7, it can be readily seen the manner in which the components of the articulated mast 10 accomplish the feature of providing a mast structure which is compact for storage yet readily converted into an operational mode. It can also be seen that in the transport mode of FIG. 1, the height of the mast and associated injector 30 is no greater than the height of the storage reel located in the dropped portion of the transport trailer.

[0028] As indicated in FIG. 4, when the system is to be transformed into the operative condition, the motor means or cylinder 27 is first expanded to tilt the injector drive portion 30 somewhat towards its final working position, at which time the hydraulic cylinder 35 is expanded to push the intermediate portion 34 of the gooseneck 31 into its operative position. At this same time, the outer end portion 36 swings to its operative position where it remains because of the form of its hinge as long as the injector drive portion continues from the position shown in FIG. 4 and until it reaches its final working position. The boom forming the lower section 16 is then moved towards its operative position by expanding of the hydraulic cylinder forming motor means 18 and activation of hydraulic cylinder forming the motor means 22 is also commended to start the raising of the boom forming the upper section 20 as indicated in FIG. 5. As the hydraulic cylinder 22 reaches its normally full extension, the upper boom is brought to its approximate final position as shown in FIG. 6. The third expandible hydraulic cylinder (not shown) is activated to telescope the extendible portions 24 to its final position, while the fourth expandible hydraulic cylinder 27 properly positions the injection drive portion 30 of the injection unit vertically over the well head structure 30 (FIG. 7).

[0029] After the drilling operation is completed, the hydraulic cylinders are operating substantially in the reverse order to place the overall tubing injection system in condition for transport (FIG. 1). It is believed apparent from the above that the system incorporating the articulated mast of the present invention is of a relatively simple design providing for economic manufacture and requiring very little work crew to put it in condition for operation or transport. The present invention is capable not only of a large reach in view of the nature and connection of the mast sections, but it also is capable of easily positioning the injector unit at a required height. It also has the desirable feature of allowing the operator to effectively and with little effort move the injector unit accurately over the well head, due to the variety of adjustments possible by the relationship of its parts and the provision of the multiple actuators.

[0030] While a single embodiment of the invention has been described variations within the spirit of the present invention as defined in the accompanying claims will be obvious to those skilled in the art.

What is claimed is:
1. An articulated mast for use in locating a tubing injection unit over a well head, said mast including:
   a lower mast section pivotally connected at one end to a carrier unit,
   an upper mast section pivotally connected at one end to a second end of said lower mast section opposite to said one end,
   an extendible mast section carried at an end of said upper mast section opposite said one end and having an outer end for supporting said injector,
   a first actuator means connected between said lower mast section and said carrier unit for raising said lower mast section from a lowered transport position disposed substantially horizontally on said deck to a more upright operating position,
   a second actuator means connected between said lower mast section and said upper mast section for pivoting said upper mast section independently of said first actuator means from a transport position immediately
overlying said lower mast section in said transport position to a raised operative position, and
a third actuator means operative independently of said first and second actuator means for moving said extendible mast section relative to said upper mast section from a retracted position to a position selectively projecting beyond said outer end of said upper mast section.
2. An articulated mast as defined in claim 1, wherein:
said carrier is a transport trailer having an upper mast supporting deck,
said lower mast section is an elongated unit having said one end connected to said deck adjacent a rear of said deck by a transverse pivot connection and wherein,
said lower mast in said lowered transport position is positioned substantially horizontally immediately above said supporting deck, and in said operating position extends upright adjacent said rear end of said supporting deck.
3. An articulated mast as defined in claim 2, wherein:
said upper mast section is an elongated unit having said one end connected to the second end of said lower mast section by a transverse pivotal connection having an axis of pivot parallel to said transverse axis connection of said lower mast section, and,
said upper mast section is an elongated unit having a lower position closely overlying said lower mast section in its lowered transport position, and in said operative position extending rearwardly of said second end of said lower mast section and at angles of attitude relative to the horizontal.
4. An articulated mast as defined in claim 3, wherein:
said extendible mast section is movable relative to said upper mast position by said third actuator means for movement between various extended positions in alignment with the attitude of said upper mast section
5. An articulated mast as defined in claim 4, and further comprising, a linkage connection at an outer end of said extendible mast providing a connection to said outer end for mounting said injection unit to thereby provide pivoting of
said injection unit about an transverse axis parallel to said transverse axis connection of each lower and upper mast section.
6. An articulated mast supporting a tubing injector unit for use on a transport carrier of the type having a rear deck portion:
said articulated mast comprising;
a lower mast section,
a first connection means connecting one end of said lower mast section to said rear deck portion for pivotal movement from a substantially horizontal position on said rear deck about a transverse axis to a raised substantially vertical position, first actuator means for raising and lowering said lower mast section between said horizontal and raised positions,
an upper mast section having a main body portion,
a second connection means for connecting a first end of said upper mast section to a second end of said lower mast section for pivotal movement of said upper mast section about a transverse axis parallel to the transverse axis of said first connecting means, said pivot movement being from a first horizontal position atop said lower mast section in said horizontal position of said lower mast section to a raised working position having upward and rearward components,
second actuator means for raising and lowering said upper mast section between said positions of said upper mast,
said upper mast section including an extendible portion at a second end thereof and connected to said main body portion of said upper mast section for telescopic movement relative thereto to provide for positioning of said extendible portion between a retracted position and an extended position for thereby increasing the length of said upper mast when in the extended position,
third actuator means for moving said extendible portion between said retracted and extended positions, and
connection means mounted on said extendible portion of said upper mast member for carrying the tubing injection unit.
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