United States Patent

[11] 3,559,905

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[21] Appl. No. 697,287
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[54] **METHOD AND APPARATUS FOR RUNNING AND PULLING A CONTINUOUS METAL MEMBER INTO AND OUT OF A WELL**
5 Claims, 15 Drawing Figs.

[52] **U.S. Cl.** **242/54,** 166/77; 242/115
[51] **Int. Cl.** **B65h 75/00**
[50] **Field of Search** 242/54, 67.1, 78.6, 115; 166/77; 175/103

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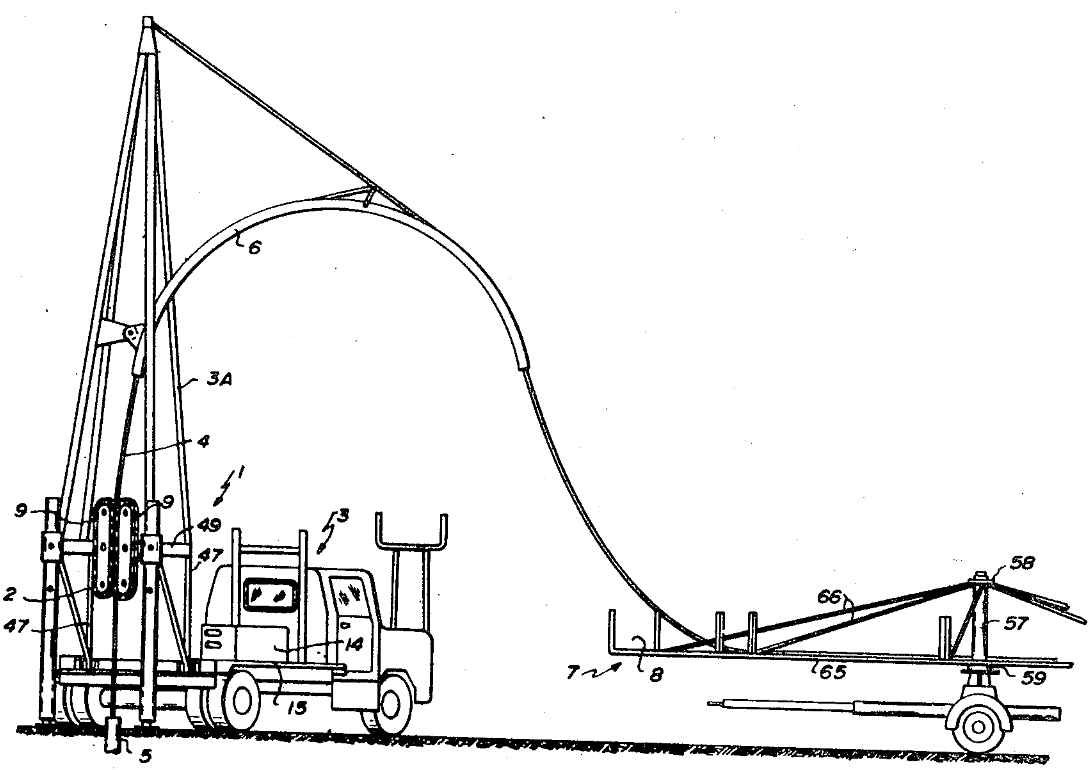
ABSTRACT: Apparatus is provided which pulls a metal member, such as a sucker rod string, from a well and coils it onto a circular frame which is of sufficient size whereby the member will not be permanently deformed. For example, a pair of opposed, driven, endless tracks, provided with gripping pads, grip the member between the pads and pull it out of the well. The member is fed to and reeled onto a rotatable, horizontal, circular channel for storage. The channel can be collapsed into a compact form for transportation.

The steps of the method are: pulling the member from the well; coiling and storing it without permanently deforming it; and running it back into the well.



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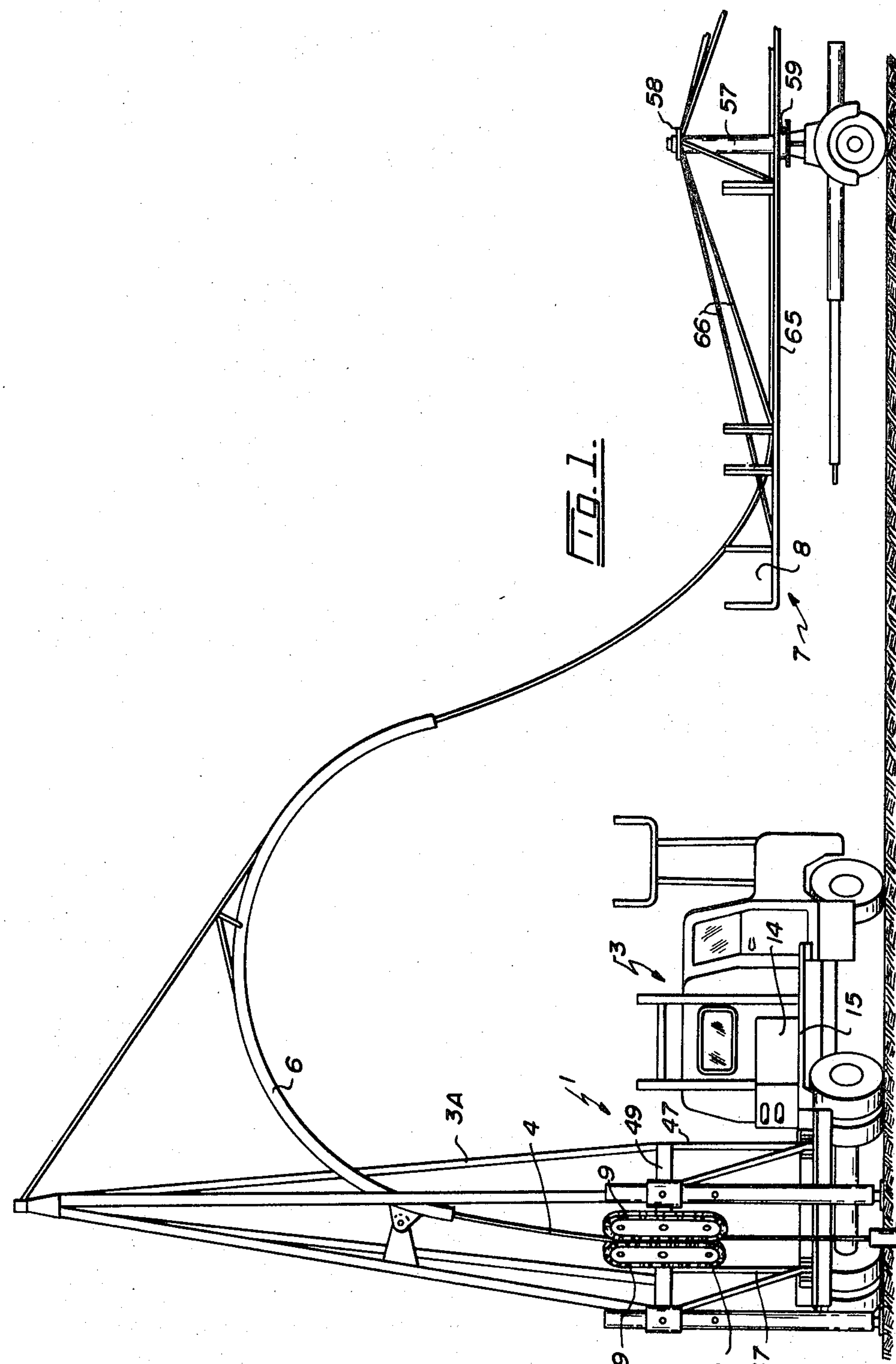

FIG. 1.

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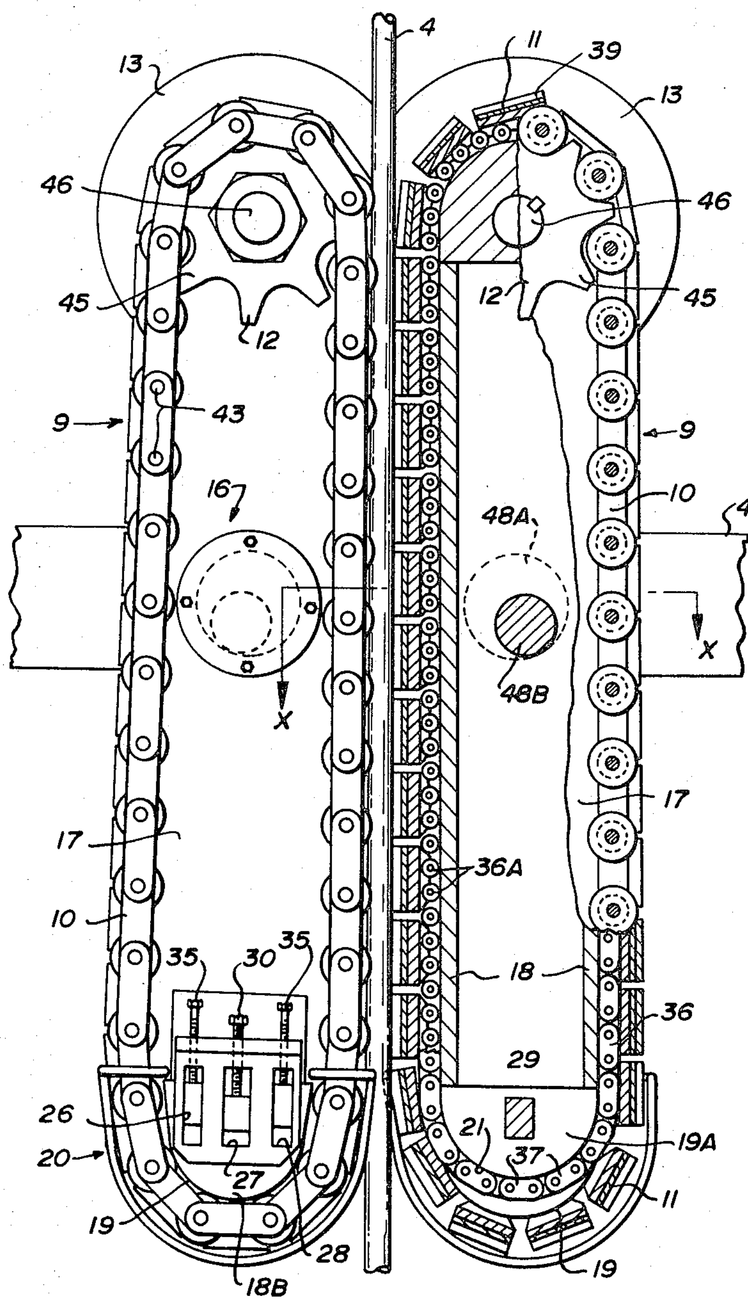

FIG. 2.

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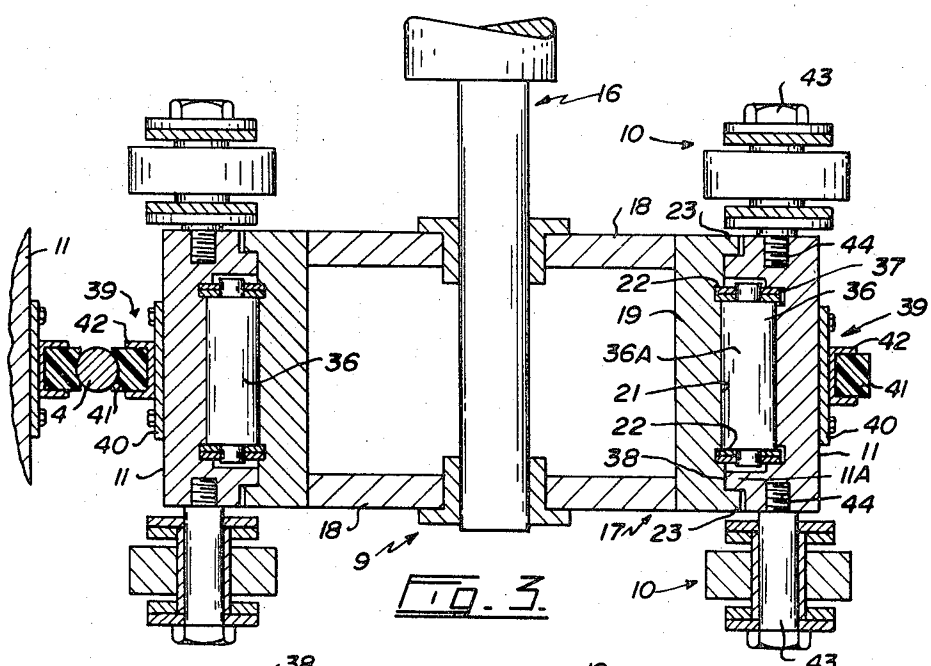

Fig. 3.

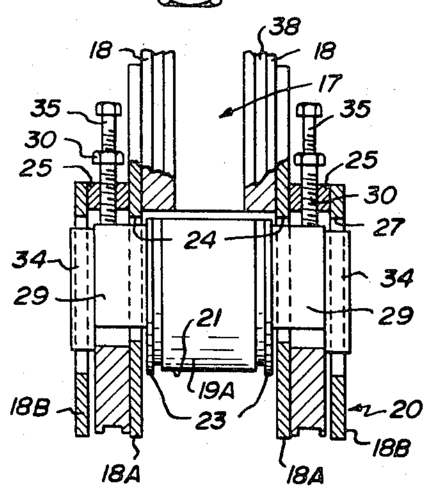

Fig. 4.

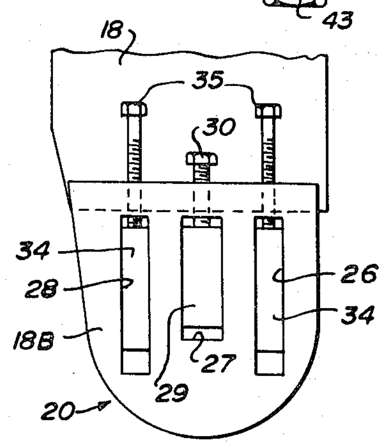

Fig. 5.

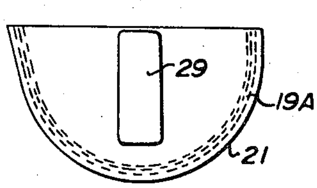

Fig. 6.

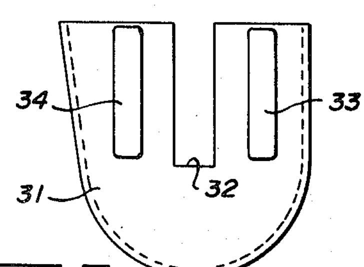

Fig. 7.

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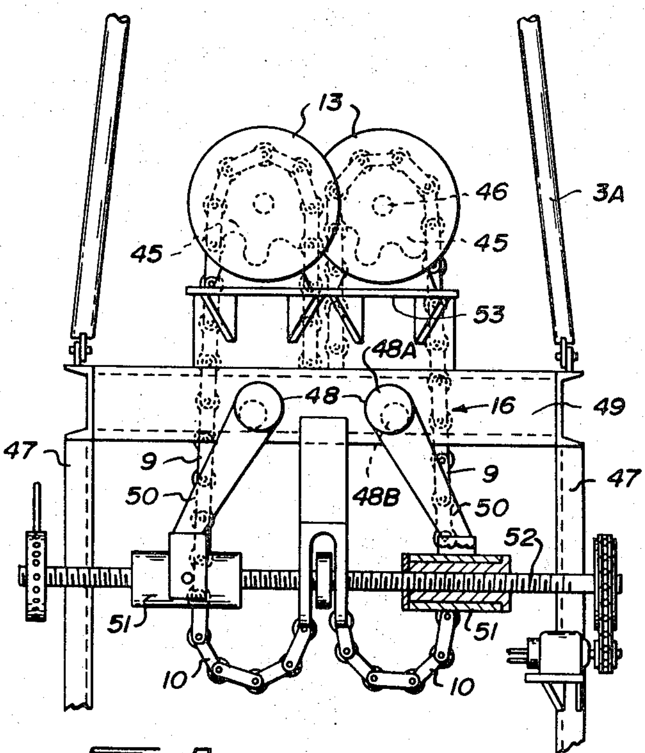

FIG. 8.

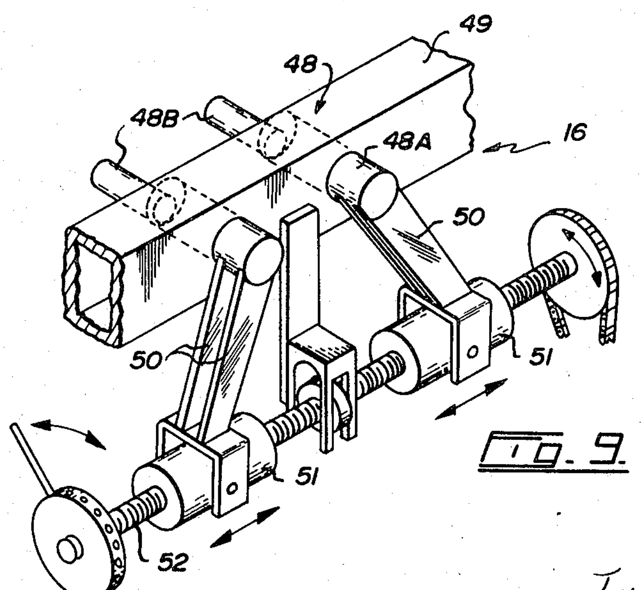

FIG. 9.

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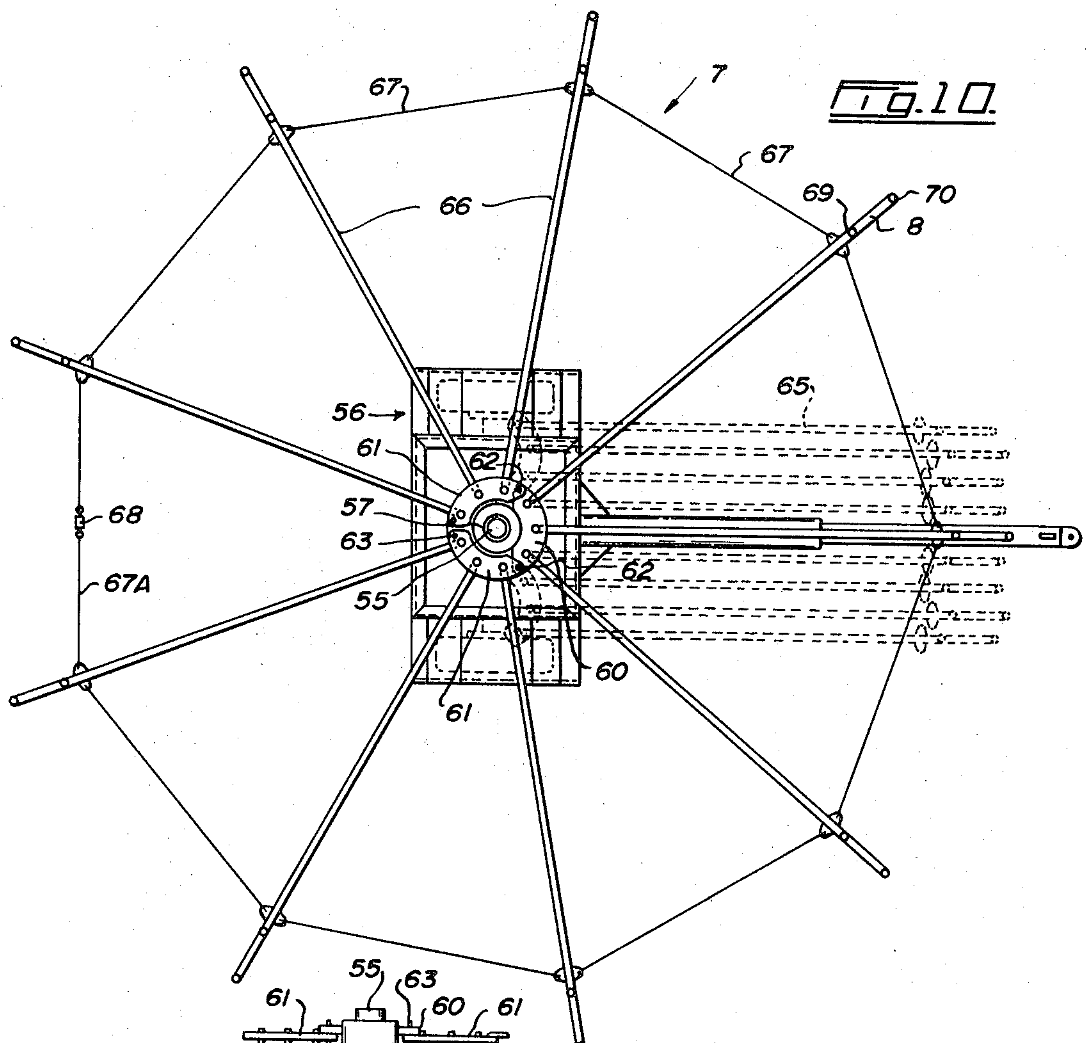

FIG. 10.

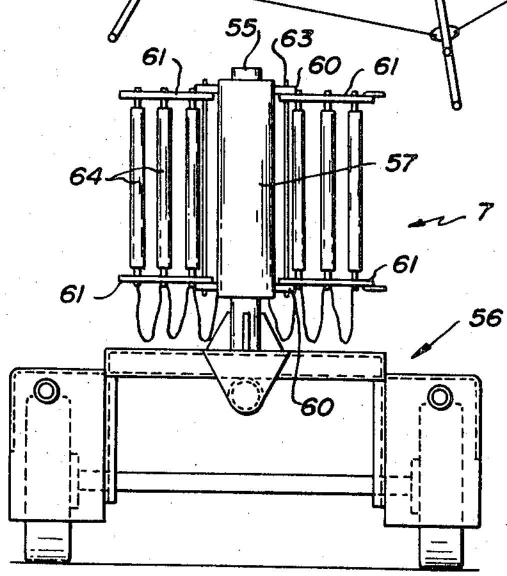

FIG. 11.

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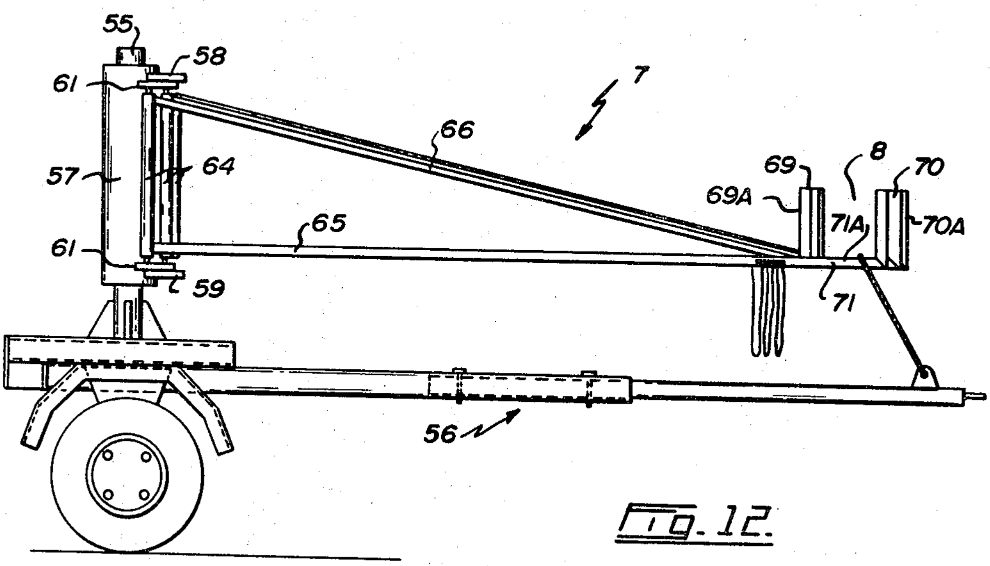

Fig. 12.

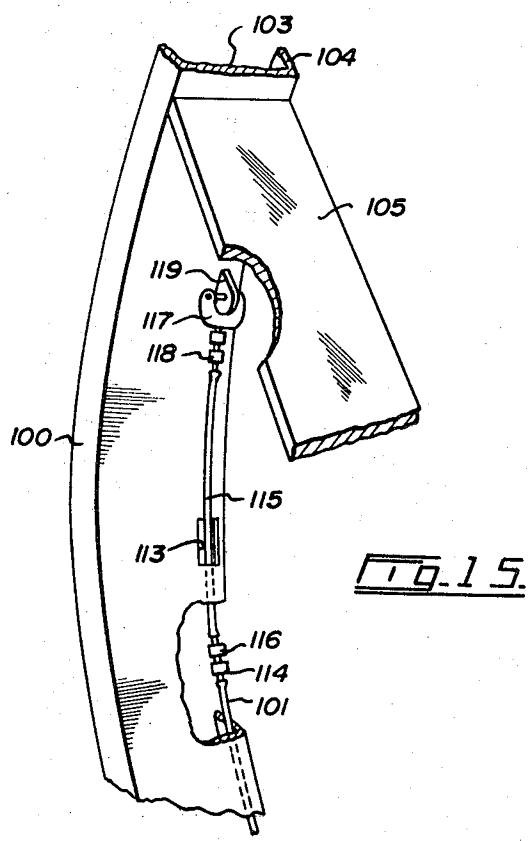

Fig. 15.

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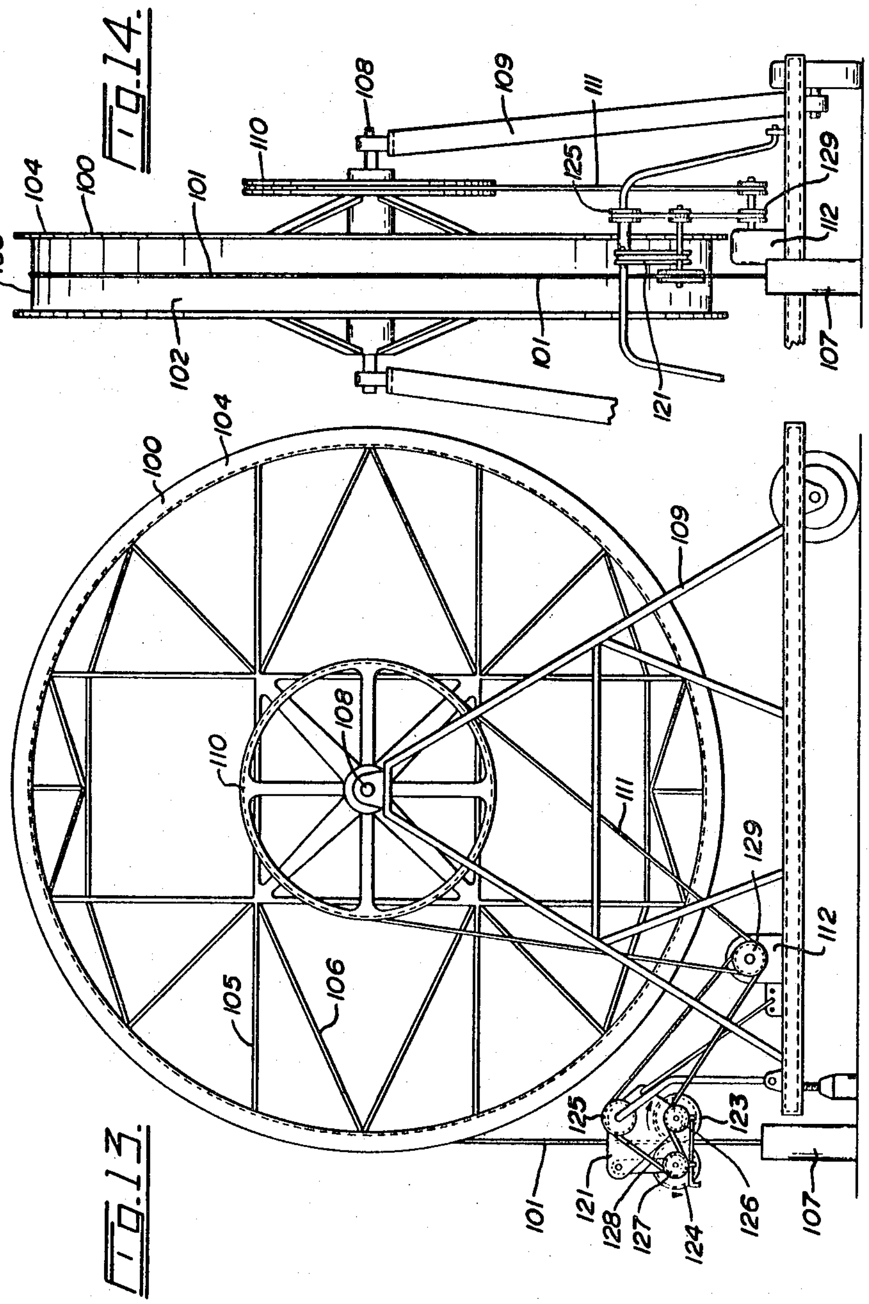

Fig. 14.

Fig. 13.

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METHOD AND APPARATUS FOR RUNNING AND PULLING A CONTINUOUS METAL MEMBER INTO AND OUT OF A WELL

BACKGROUND OF THE INVENTION

This invention relates to an apparatus and a method for pulling, running and storing a onefold, metal member, such as a continuous sucker rod string, which can be used in oil and water wells and the like.

Sucker rods have long formed an essential part of the equipment used in wells to pump fluid therefrom. A plurality of these sucker rods are connected end to end to form a "string." The rod string is, in turn, suspended within a string of tubing disposed within the well. Now, the rod string is usually attached at its lower end to a bottom hole pump seated in the bottom of the tubing string. At its upper end, at ground surface, the rod string is connected to a reciprocating mechanism, such as a pump jack. Upon reciprocation of the rod string by the pump jack, the bottom hole pump is actuated and fluid is pumped to the surface through the annular space existing between the rod string and the inner wall of the tubing string.

A conventional sucker rod string is made up of a plurality of individual rods connected end to end. Each sucker rod is about 25—30 feet in length and is provided with a threaded pin at one end and a threaded box at the other. The pin of one sucker rod is screwed into the box of the next sucker rod to make the connection.

A conventional sucker rod string has a number of disadvantages. For example, the threaded pin is inherently a weak member. Upon undergoing the repeated cyclic stresses to which a sucker rod string is subjected in use, parting of the rod periodically takes place at the pin. Additionally, the pins and boxes are relatively difficult to machine and errors in the machining can lead to improperly fitted pins and boxes with increased risk of failure. In order to provide suitably durable pins and boxes, it is necessary to construct them with a substantially greater diameter than the diameter of the sucker rod. Now, couplings of increased diameter create problems. For example, a sucker rod string equipped with couplings of increased cross section will drop through fluid more slowly in comparison with the same rod string without enlarged couplings. As a result, the pumping rate of the bottom hole pump can be deleteriously effected. This is particularly a problem in oil wells producing low gravity crude. Additionally, there is obviously more metal required in manufacturing the enlarged pin and box coupling.

Since a rod string is usually several thousand feet long and is made up of a large number of individual rods, tripping of the string in and out of the well is a time consuming and expensive operation. A service rig, having a crew of at least three men, has to be used. When pulling the string, the rods have to be broken out individually or in small units of two or three and stacked on the ground or in the rig derrick. Similarly, when running them, they have to be picked up and made back up.

It has been proposed in the prior art to use onefold or single component metal sucker rod strings in wells to overcome the aforementioned difficulties. Such strings do not, of course, have the enlarged couplings used in conventional strings. They also have the potential for rapid tripping since they are not comprised of a plurality of joints which have to be broken apart or screwed together. However, no satisfactory servicing apparatus has, as yet, been disclosed for use with such rod strings. As a result, onefold sucker rod strings have not yet won commercial acceptance.

In my opinion, to be of practical value, a servicing apparatus for use with such strings would have to meet the following tests:

a. It must be capable of pulling and running the rod string repeatedly without seriously damaging it. In some oil fields, the bottom hole pump has to be changed as often as six times a year; yet well operators expect the rod string to last a year or longer without breakdown.

Now, reel-type servicing apparatuses have been proposed in the prior art for use with continuous "macaroni" strings (these are strings comprised of small diameter hollow tubing which are run into wells to circulate sand bridges out). It might be felt that these apparatuses would be suitable for servicing onefold rod strings. However, the apparatuses are characterized by a common feature: they propose winding the macaroni string, when pulled from the well, onto a small, upstanding drum. The string is permanently deformed or bent as a result of this act and straightening rolls have to be provided to straighten it when it is being fed back into the well. Because of the severe cold working, the string becomes embrittled and soon parts in use. Such an apparatus would not be satisfactory for use with a onefold rod string.

b. It must be capable of rapid assembly and operation. A service rig will commonly service the rod strings of more than one well in a working day. It is doubtful whether the concept of the use of a onefold sucker rod string would win acceptance in industry if the apparatus for servicing it were not as "fast" as existing equipment used in conjunction with conventional rod strings.

c. The apparatus must be capable of being transported without problems. Servicing apparatus is inherently heavy and bulky since the rod strings it pulls usually weigh many thousands of pounds. This means that provision must be made to ensure that the apparatus will not exceed relevant highway regulations pertaining to weight, width and height.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to provide an apparatus which is mobile, which can be quickly rigged up and down, and which can rapidly trip the continuous metal member without damaging it.

Now, the invention utilizes the concepts of coiling the pulled onefold metal member as a means of storing it and of coiling it on a frame which is so adapted as not to permanently deform it, in order that the member may be serviced again and again. Apparatus is provided which comprises a practical, mobile means for carrying these concepts into effect.

This apparatus comprises means adapted to pull a onefold metal member, such as a metal sucker rod string, out of a well, to form it into a coil, to support and store it in that form without stressing it beyond the 0.2 percent offset yield of the member, and to run it back into the well.

In one embodiment, the apparatus may comprise a driven drum, rotatable about a horizontal axis, which is adapted to be positioned adjacent the well, and, upon being connected to the upper end of the string, can be rotated in one direction to reel the string onto itself and, subsequently, can be rotated in the opposite direction to feed the string back into the well. Alternatively, the apparatus may be comprised of a combination of two units. One unit will comprise means, such as a pair of endless, driven tracks gripping the string between them, adapted to pull and run the string out of and into the well. The other unit will comprise means, such as a rotatable, circular support surface, positioned adjacent the well and adapted to receive the string from the first means and to coil and store it. It is important to note that, regardless of the embodiment, the coiling and storing must take place on a support surface which is of sufficiently large diameter whereby the rod string will not be permanently deformed or bent when coiled thereon. Using such a servicing structure, the string may be repeatedly pulled and run without danger of embrittlement and subsequent failure.

In accordance with the preferred embodiment of the invention, a collapsible coiling and storing unit (referred to hereinafter as the storing unit) is combined with a separate pulling and running unit (referred to hereinafter as the pulling unit) to provide a readily transportable, "fast," lightweight servicing apparatus. The storing unit can be quickly converted from a transport position to a operating position.

In a particularly preferred form of this preferred embodiment, an upstanding shaft is provided which can be set on the ground or remain mounted on a truck bed. A collar is rotatably carried by the shaft. This collar is divided into pivotally connected segments which can be locked together embracing the shaft, in the operating position or which can be folded to a transport position wherein the segments are disposed in line on one side of the shaft. A plurality of substantially horizontal, outwardly extending, radial struts are pivotally mounted at their inner ends on the collar. Means are provided for maintaining the outer ends of the struts in fixed, spaced-apart relation when in the operating position. By virtue of their pivotal mounting, the struts can be swung together into a closely packed, parallel position when the collar segments are in the transport position. A ringlike storage channel, comprised of a substantially horizontal support surface bounded by upstanding inner and outer retaining elements, is defined at the outer end of the struts. The horizontal support surface is conveniently provided by the upper surfaces of the struts themselves. The retaining elements are formed of spaced, upstanding inner and outer posts mounted on the struts. The diameter of the circle defined by the inner posts is large enough whereby, when the rod string is stored in the channel, it will not be stressed beyond its 0.2 percent offset yield.

The pulling unit will include a pair of vertically disposed, opposed, transversely adjustable, driven tracks adapted to be located over the well head. The tracks include suitable gripping elements for gripping the rod string. Upon actuation of the tracks, the gripping elements will act to grip and pull the rod string vertically out of the well and feed it, preferably through a curved rod guide, to the rotatable storage channel for reeling thereon. Upon reversing the direction of travel of the tracks, they will act to withdraw the rod string from the storage channel and feed it back into the well.

For the purposes of this disclosure, the term "stress diameter" is intended to mean the diameter of the surface which forms the rod string into a coil. For example, in the case of the preferred embodiment wherein a horizontal storing channel is used, the stress diameter will be the diameter of the circular, inner retaining element or boundary of the channel. In the case where an upstanding drum is used, the stress diameter will be the diameter of the circumferential surface of the drum which supports the rod string.

When the expression "servicing" is used herein, it is considered to cover the tripping of the rod string in and out of the well.

Throughout the disclosure, expressions such as "diameter" and "circular" are used in describing the configuration of the storing unit. It is to be understood that deviations from a perfectly circular configuration, such as the use of a slightly oval or polygonized structure, are considered within the scope of the invention. Therefore, the words "diameter" and "circular" are to be stretched beyond their literal meanings for the purposes of this specification and are intended to apply to frame configurations which are generally circular, as well as to frames which are perfectly circular in configuration. Additionally, the description is mainly directed to the apparatus and its use with metal sucker rod strings. However, the invention may be embodied in apparatus suitable for servicing other continuous metal members such as "macaroni" strings. Such embodiments are considered within the scope of the invention.

DESCRIPTION OF THE DRAWINGS

In drawings which illustrate the embodiments of the invention:

FIG. 1 is a perspective view showing the pulling unit, rod guide and part of the storing unit as they would appear in operation;

FIG. 2 is a side view of the track members of the pulling unit, the track member on the right hand side being illustrated partly in section;

FIG. 3 is a transverse cross-sectional view of the track members taken along the line X–X in FIG. 2;

FIG. 4 is a partial, longitudinal, cross-sectional view of the lower end of the track member box frame;

FIG. 5 is a partial, side view of the lower end of the track member box frame;

FIG. 6 is a side view of the bearing surface extension;

FIG. 7 is a side view of the adjustment plates;

FIG. 8 is an end view, partly in section, of the motor and eccentric assemblies;

FIG. 9 is a perspective view of the eccentric assembly showing the box frame, from which it is suspended, in shadow lines;

FIG. 10 is a top view of the storing unit in the operative position, with the parts shown in shadow lines in the transport position;

FIG. 11 is an end view of the storing unit in the transport position;

FIG. 12 is a side view of the storing unit in the transport position;

FIG. 13 is a side view of an alternative embodiment of the invention;

FIG. 14 is a front view of the apparatus shown in FIG. 13;

FIG. 15 shows a broken-away portion in perspective of the drum illustrated in FIG. 13. One means for connecting the drum and rod string is shown.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Turning now to the specific embodiment of the invention shown in FIG. 1, a pulling unit **1**, which includes a track assembly **2** carried by a mobile support unit **3**, is illustrated. A onefold, metal sucker rod string **4** is shown extending upwardly out of well **5**. Rod string **4** is gripped in track assembly **2** and extends through rod guide **6** to storing unit **7** upon which it can be coiled, without permanent deformation, within channel **8**. In operation, rod string **4** is pulled from well **5** by track assembly **2** and fed through rod guide **6** into rotatable channel **8** for coiling and storage therein.

The Pulling Unit

Track assembly **2**, shown in FIGS. **2** and **3** in greater detail, provides the means for gripping and pulling rod string **4** from well **5**. It includes the actuating assemblies for operating such means. In greater detail, track assembly **2** includes two vertically disposed, opposed track members **9** which are suspended above the ground from derrick **3A**. Each track member **9** includes a pair of parallel sprocket chains **10** carrying between them a series of gripping pads **11**, adapted to grip rod string **4**. Drive sprocket assemblies **12**, connected to hydraulic motors **13**, are provided to drive sprocket chains **10**. A pump assembly **14** is mounted on truck **15** and is adapted to provide fluid under pressure to drive hydraulic motor **13**. An eccentric assembly **16** is provided to move track members **9** transversely and thereby adjust the gripping force of gripping pads **11**.

Track members **9** will now be described in greater detail. Each member **9** has an elongate box frame **17** as its core. Frame **17** is rounded at its upper end and includes an extension assembly **20** at its lower end for adjustment of its overall length. As shown, frame **17** is formed of side members **18** and bearing members **19**, so named because they form a support surface upon which the gripping pads **11** move. As best shown in FIG. 4, bearing members **19** and extension assembly **20** define a central, continuous, smooth, rounded bearing surface **21** bounded by indented grooves **22** and upstanding shoulders **23**. As will be described hereinbelow, bearing surfaces **21** support a chain **36** of connected needle bearings and the gripping pads **11** while shoulders **23** act as a bearing surface to support sprocket chains **10**.

Dealing now with the extension assembly **20** shown in FIGS. **4**, **5**, **6** and **7**, it includes two rounded side plates **18A** welded to side members **18**. A longitudinal slot **24** is defined in each side plate **18A**. A rounded side plate **18B** is connected in parallel, spaced relationship with each side plate **18A** by spacer 25. Three parallel, longitudinal slots 26, 27 and 28 are defined in each side plate 18B. A rounded bearing surface extension 19A, shown in FIG. 6, is fitted between side plates 18A. Bearing surface extension 19A is provided with integral transversely projecting lugs 29 which run in slots 24 of side plates 18A. Bolts 30, extending through spacers 25, are threaded into lugs 29 and serve to adjust the longitudinal position of bearing surface extension 19A. A pair of adjustment plates 31 are inserted in the grooves defined between side plates 18A and 18B. As shown in FIG. 7, each adjustment plate 31 defines an open slot 32, adapted to slip over lug 29. A pair of integral lugs 33, 34 project outwardly at each side of each slot 32 and these lugs register in the slots 26, 28 of the side plates 18B. Bolts 35 extend through spacers 25 and thread into lugs 33 for adjusting the position of adjustment plates 31. By virtue of this construction, bearing surface 21 and shoulders 23 may be independently extended to tighten or loosen the chain assemblies mounted thereon.

A stationary, linked chain 36 of needle bearings is supported on the bearing surface 21 and bearing surface extension 19A. As illustrated in FIG. 2, the bearings 36A of chain 36 are connected by links 37 which extend into indented grooves 22 for alignment thereof.

Gripping pads 11, connected to sprocket chains 10, ride on needle bearings 26A. Pads 11 are flat faced and have downwardly depending shoulders 11A which ride in guide grooves 38. Each pad includes a gripping assembly 39 mounted on its outer face. Each gripping assembly 39 comprises a base plate 40, bolted to pad 11, and a flat gripping element 41 carried in a channel member 42 which is welded to base plate 40. Since element 41 has to friction grip the oily rod string 4, it should be characterized by good abrasion and oil resistance and a desirable load-bearing capacity. Additionally, the element 41 will preferably be made of somewhat flexible material in order that it may be used with rod strings of varying diameters. An element 41 formed of urethane elastomer having a Shore durometer range of D-50 has been shown to be suitable.

As previously mentioned, gripping pads 11 are connected to and are carried by sprocket chains 10 which ride on shoulders 23. Sprocket chains 10 are of the hollow pin, bushed type, They are connected to pads 11 by bolts 43 which thread into bores 44. The chains 10 are propelled by sprocket assemblies 12. Each such assembly 12 includes a pair of sprocket wheels 45 mounted, one on each side of box frame 17, on axles 46. Axles 46 are, in turn, connected to and are driven by hydraulic motors 13.

The means illustrated for supporting track assembly 2 over well 5 will now be described. Such means includes a derrick 3A from which track members 9 are suspended. The vertical legs 47 of derrick 3A are pinned to and are supported by the bed of truck 15. A horizontal box frame 49 is welded to legs 47 and bridges the gap between them at a point spaced above the truck bed. Track members 9 are suspended from box frame 49 by shafts 48. These shafts 48 form a part of eccentric assembly 16, which will now be described.

Eccentric assembly 16 comprises the means provided to move tracks 9 toward and away from one another so as to accommodate different sizes of rod and to vary the pressure, and thus the grip, exerted on rod string 4 by gripping pads 11. The said assembly 16 includes shafts 48. Each shaft 48 is divided into an inner segment 48A and an outer segment 48B. Inner segments 48A extend through bearings mounted in horizontal box frame 49 and outer segments 48B extend through bearings mounted in vertical box frame 17. As illustrated, outer segments 48B are of reduced cross section in comparison to inner segments 48A and their center axis are offset from the center axis of segments 48A. Means are provided for rotating inner segments 48A. Upon rotation of these inner segments, an eccentric movement of outer segments 48B takes place. This eccentric movement causes an increase or decrease in the dimension of the gap defined between track members 9. The means for rotating inner segments 48A includes arms 50 which are keyed at their upper ends to the said segments. Arms 50 are pivotally connected at their other ends to sleeves 51. Sleeves 51 are, in turn, threadably mounted on threaded shaft 52. One sleeve 51 is provided with a right-hand thread and the other is provided with a left-hand thread. Upon rotation of shaft 52, sleeves 51 move in opposite directions, thereby rotating shafts 48 and moving tracks 9.

A pair of hydraulic motors 13 are mounted on supports 53 attached to box frames 17. Each motor 13 drives one track member 9 through a drive shaft 46. Radial, reciprocating-type piston hydraulic motors, having a high torque output at low speeds, are suitable for the purposes of the apparatus. For example, motors rated up to 100 r.p.m. having a peak torque of 5,000 pounds have successfully been used in pulling 5,700 feet of ¾-inch rod. A pump 14 is provided to supply fluid under pressure to motors 13. Conventional equipment will be used to control the speed, power output and direction of rotation of the said motors.

As mentioned hereinabove, derrick 3A is mounted on a truck or trailer bed. It is shown hinged at its base whereby it may be laid down when the unit is to be moved. The only function of the upper end of the derrick 3A is to provide means from which rod guide 6 may be suspended. If desired, rod guide 6 could be supported from below and the upper section of derrick 3A eliminated from the apparatus.

THE ROD GUIDE

The rod guide 6 comprises a closed tube which serves to gradually change the direction of the rod string 4 from the vertical position in which it emerges from the well 5 to a horizontal position for feeding into storing unit 7. The curvature of rod guide 6 is sufficiently gentle whereby it will not stress the rod string passing through it beyond its 0.2 percent offset yield.

THE STORING UNIT

The storing unit 7 is characterized by two features, one critical and the other preferred. It must be of sufficient diameter whereby the rod string 4, when coiled thereon, is not stressed beyond its 0.2 percent offset yield. It should be collapsible to an easily transportable form.

A preferred embodiment of the storing unit 7 is shown in FIGS. 10, 11 and 12. The unit is self-reeling in use and provides a horizontal storage surface upon which the rod string 4 may be laid. In greater detail, the unit includes a vertical shaft 55 which is shown fixed on the bed of a pole trailer 56. Shaft 55 carries a rotatable sleeve 57 free to turn easily thereon by virtue of roller bearings (not shown) disposed between the two. Top and bottom collars 58, 59 are mounted on sleeve 57. Each such collar is comprised of a fixed segment 60, which is welded to sleeve 57, and two movable segments 61 which are secured to segment 60 by pins 62. Segments 61 can swing on pins 62 to a transport position. In this transport position they are linear with fixed segment 60, as shown by the shadow lines in FIG. 10. In the operating position, segments 61 are locked in place, embracing sleeve 57, by pins 63. A plurality of vertical bars 64 are mounted in openings in the top and bottom collars 58, 59. These bars are free to turn about their longitudinal axis. Outwardly extending, horizontal, radial struts 65 are welded to the bottom ends of bars 64. Cross braces 66, extending from adjacent the outer end of struts 65 to the upper ends of bars 64, serve to strengthen the load-carrying capacity of the said struts. In the operating position, struts 65 are maintained in spaced-apart relationship, as shown in FIG. 10, by cables 67. A snap 68 is provided in the middle of one cable 67A for rapid assembly or disassembly of the spacing means. To convert storing unit 7 from the operating position to the transport position, snap 68 is unhooked, movable segments 61 are swung into line with fixed segment 60 and struts 65 are crowded together into the closely packed, parallel formation shown in shadow lines in FIG. 10.

A storing channel **8** is carried by radial struts **65**. As illustrated in FIG. **12**, a plurality of vertical inner and outer posts **69**, **70** are mounted in spaced apart relationship adjacent the outer ends of radial struts **65**. These posts serve to define the boundaries of storing channel **8**. The upper surfaces of the segments **71** of radial struts **65**, extending between posts **69**, **70**, comprise the support surface **71A** upon which rod string **4** will rest. To summarize, channel **8** comprises a ringlike, horizontal support surface **71A** bounded by circular upstanding inner and outer retaining elements **69A**, **70A** comprised of a plurality of spaced posts **69**, **70**.

The diameter of the circle defined by inner posts **69** is sufficiently large whereby the rod string **4**, when coiled within channel **8**, will not be stressed beyond the 0.2 percent offset yield. In the diameter, modulus of elasticity, offset yield stress of the rod material and the distance from the neutral axis of the rod to its surface are known, a suitable diameter for the said circle may be calculated by using the following equation:

$$D=2Ec/S$$

Where:

S = maximum unit stress, pounds per square inch, for the rod string;

c = distance, in inches from the neutral axis of the rod to its surface; and

E = modulus of elasticity of the rod in pounds per inch.

The above equation is not intended to comprise a critical limitation on the invention. It is provided as a rough mathematical aid which may be used in designing a storing channel which will coil and store a rod string of a particular size without danger of permanent deformation occurring.

It will be understood that the horizontal disposition of channel **8** is only a preferred condition. It may be inclined or vertical.

OPERATION

In the servicing of a well **5** containing a onefold rod string **4**, the first steps will involve suspending the string from a clamp seated on the wellhead and then disconnecting the pump jack from the string. The upper end of the rod string **4** will thereby be left projecting upwardly out of the wellhead. The pulling unit **1** will then be backed up to the wellhead so that the track members **9** bracket the exposed end of the rod string **4**. Eccentric assembly **16** will be actuated by turning threaded shaft **52** to move track members **9** together until they grip rod string **4** tightly between their gripping elements **41**. Rod guide **6** will be suspended from derrick **3A**. One end of rod guide **6** will be slipped over the upper end of rod string **4**. Storing unit **7** will be assembled in the operative position as hereinabove described. It will be positioned at the free end of rod guide **6**. The apparatus is now assembled and ready to pull the rod string **4** from well **5**. Fluid pressure will be supplied to hydraulic motors **13** from pump **14**. This actuation of motors **13** will cause sprocket assemblies **12** to rotate and drive sprocket chains **10**. Gripping elements **14** will thereby be moved and will commence feeding rod string **4** out of well **5**. The end of rod string **4** will be fed by rod guide **6** onto the support surface **71A** of storing channel **8**. Upon tying the end of the rod string **4** to one of the posts **69,70**, the feeding of the rod string **4** into channel **8** will cause it to be rotated. In other words, storing unit **7** will become self-reeling. Pulling, coiling and storing will continue until the bottom hole pump has reached the surface. The pump will be disconnected from the rod string **4** and a new one substituted for it. The gripping elements **41** will then be driven in the opposite direction to feed the rod string **4** back into well **5**.

ALTERNATIVE EMBODIMENT

An alternative embodiment of the apparatus is shown in FIGS. **13**, **14** and **15**. As illustrated, an upstanding drum **100** is provided for running, pulling, coiling and storing the rod string **101**.

Drum **100** includes circumferential channel member **102** having a floor **103** and sides **104**, floor **103** forms the circumferential surface of drum **100**. Channel member **102** is wide enough and deep enough to accommodate sucker rod string **101** which is to be reeled and stored thereon.

The ringlike channel member **102** is rigidly braced by a drum substructure composed of chord members **105** and struts **106**. It is readily apparent that various arrangements for bracing channel member **1** or **2** may be used. Drum **100** has to be capable of supporting the weight of sucker rod coiled thereon at any particular moment. Additionally, it will have to be designed to withstand the effect of tangential load exerted by the remainder of sucker rod **101** suspended in well **107**.

Drum **100** is rotatably mounted on an axle assembly **108** carried by drum carrying frame **109**. Frame **109** includes a wheeled transportation means such as the trailer shown. Drum **100** is mounted so as to extend out over one end of frame **109**. When frame **109** is properly positioned adjacent well **107**, the edge of channel member **102** will be positioned directly over rod string **101**.

Suitable means for rotating drum **100** to reel rod string **101** thereon are illustrated. Such means include a sheave **110** driven by a belt **111** and prime mover **112**.

Means are provided to connect rod string **101** with drum **100**. One such means is illustrated in FIG. **15**. Slot **113** is provided in floor **103** of circumferential channel member **102**. A threaded pin **114** is welded to the end of rod string **101** and is connected to pony rod **115** by coupling **116**. Pony rod **115** is connected to yoke **117** by coupling **118**. Yoke **117** is, in turn, suspended from eye **119**, mounted on drum **100**, by pin **120**.

Means may be provided to aid drum **100** in pulling rod string **101** out of well **107**. Such a means is illustrated in FIGS. **13** and **14**. It includes a plate **121** attached to frame **122**. Plate **121** supports two friction rollers **123**, **124** and an idler roller **125**. The axes of friction rollers **123**, **124**, which are equal in size, are located in the same horizontal plane. The minor surfaces of rollers **123**, **124** are aligned in a vertical plane and are slightly spaced apart so that rod string **101** may be fed between them. Friction rollers **123**, **124** are fixed to plate **121**. However, friction roller **124** may be moved from one fixed position to another on plate **121** to vary the space between it and friction roller **123**. The extent of friction grip on rod string **101** may therefore be varied. As illustrated, idler roller **125** is secured to plate **121** at a point directly above friction roller **123**. Friction rollers **123**, **124** each carry a sheave **126**, **127** respectively. Belt **128** connects power means sheave **129** and sheaves **126**, **127**. As shown in FIG. **13**, belt **128** is passed across the top of sheave **126**, across the bottom of sheave **127** and over idler roller **125**. As a result of this arrangement, friction rollers **123**, **124** will rotate in opposite directions when belt **128** is actuated and may be rotated to aid in pulling rod string **101** out of well **107**. Those skilled in mechanical arts will be able to determine the sheave sizes required whereby rod string **101** is pulled from well **107** at the same rate of speed with which it is taken up by the drum **100**.

Drum **100** must have a diameter such that, when string **101** is reeled thereon, the deformation of it is less than that amount required to cause stress in it beyond the 0.2 percent offset yield.

FEATURES AND UTILITY

The apparatus is characterized by three advantageous features. Firstly, it does not permanently deform the rod string which it services; as a result the string can be tripped time and again without problems. Secondly, it can be quickly rigged up and dismantled and is mounted on a suitable conveyance for portability. Thirdly, it can pull and run the rod string at a speed at least equal to conventional equipment. The second and third features add up to a servicing unit which is "fast," and therefore desirable for well servicing work.

An apparatus in accordance with the preferred embodiment described hereinabove has been field tested in the following manner:

A onefold metal sucker rod string approximately 5,700 feet in length was made up of the following:

14 coils, totaling 2,980 feet in length, of ⅝-inch diameter metal sucker rod;

2 coils, totaling 350 feet in length, of 21/32-inch diameter metal sucker rod;

1 coil, totaling 311 feet in length, of 11/32-inch diameter metal sucker rod;

11 coils, totaling 2,050 feet in length, of ⅝-inch diameter metal sucker rod.

The coils were all made of AISI 4621 steel.

The coils were flash butt welded end to end and accumulated on a single reel approximately 7 feet long having an inner diameter of 32 inches. This long coil was then shipped to an oil well located in Alberta Canada.

At the welsite, the rod was unreeled from the drum in lengths of approximately 400 feet. Each 400-foot length was anchored at the drum end and a hydraulic press was used to stretcher straighten the length by pulling on it at the opposite end. As each length was straightened, it was reeled onto a drum, in accordance with the alternative embodiment, having a diameter of 24 feet. The drum was 1 foot wide. After the entire coil was straightened and reeled onto the drum, the drum was moved into location over the wellhead. A bottom hole pump was connected to the end of the rod by an overshot.

The drum was driven by a slow speed, high torque, hydraulic motor. Power for the motor was provided by a high pressure, reciprocating, variable volume pump driven by a truck power-take-off. The rate of delivery of fluid to the pump was regulated by the speed of the truck engine.

The pump and downwardly tapered, onefold, straight, metal sucker rod were continuously fed into the well at a rate as high as 100 feet per minute by rotating the drum. Once the pump was seated in the bottom of the tubing, the rod was cut at a point several feet above the wellhead and a length of tubular polish rod was fitted over, and secured to, the upper end of the rod string. A conventional stuffing box was secured in place to seal the annular space between the polish rod and the well tubing. A clamp was then fitted to a short section of the rod extending above the polish rod and a pump jack bridle attached below the clamp. The pump jack was then put into operation and the bottom hole pump successfully actuated.

During the subsequent 6-month period, the rod string was serviced using an apparatus in accordance with the preferred embodiment at least 12 times. These trips were carried out to check the condition of the rod string and to perfect the techniques of servicing. Throughout this period, the rod string continued to operate without problems.

The rod string was pulled by the apparatus at speeds up to 200 feet per minute. In addition, the apparatus was rigged up in periods as short as 45 minutes from the time upon which it was driven up to the well, using a 2-man crew. It was dismantled in periods as short as 15 minutes.

There are other features arising from the structure of the apparatus. By using flexible, flat elastomer gripping elements, rod strings having varying diameters, such as tapered strings, may be serviced without any interchange of parts. The track members are simply adjusted to grip the section of differing diameters when it is reached. In addition, the storing reel of the preferred embodiment is self-winding. This is of advantage since a driven reel has to be synchronized with the pulling unit. Synchronization involves mechanical difficulties which are self-evident and which will not be discussed herein. Additionally, the use of separate pulling and storing units has an important advantage. The storing unit, which is the largest item of equipment, can therefore be made of light, collapsible construction. This greatly increases the mobility and ease of installation of the entire apparatus.

Method

The method in accordance with the invention includes the steps of pulling the onefold metal member out of the well and simultaneously forming the pulled member into a coil which is stored without stressing it beyond its 0.2 percent offset yield. Subsequently, when the member is to be rerun, it is withdrawn from the storing means and fed back into the well.

I claim:

1. In combination:

a substantially rigid onefold member adapted to be disposed in a well;

pulling means adapted to engage and pull the member out of a well, to feed the member to a storage means and to withdraw it from a storage means and run it back into a well;

reel storage means of a diameter which is adapted to form the member fed to it into a coil of a predetermined diameter and to store it in that form without it being stressed beyond its 0.2 percent offset yield wherein the member powers the storage reel and synchronizes the feed with the storage reel.

2. In combination:

a substantially rigid onefold member adapted to be disposed in a well;

pulling means adapted to engage and pull the member out of a well, to feed the member to a storage means and to withdraw it from a storage means and run it back into a well;

reel storage means of a diameter which is adapted to from the member fed to it into a coil of a predetermined diameter and to store it in that form without it being stressed beyond its 0.2 percent offset yield wherein the storage reel is a freely rotatable reel and the feeding of the member on and off thereof provides the sole motivation of the reel.

3. Apparatus for running and pulling a onefold metal member into and out of a well and for storing it which comprises, in combination:

A storing assembly comprising:

a. a rotatable circular channel having a support surface for receiving and supporting the onefold member and spaced inner and outer retaining elements forming the boundaries of the support surface, said elements adapted to form the onefold member fed onto the support surface into a coil, the diameter of the inner retaining element being large enough whereby the onefold member when stored therearound is stressed less than its 0.2 percent offset yield; and

b. a pair of vertically disposed, opposed, transversely adjustable, driven tracks carrying means for gripping the onefold member, the tracks being adapted to abut the onefold member above the wellhead to grip it between the gripping means and, when driven in one direction, to pull the onefold member out of the well and feed it to the storing assembly and, when driven in the other direction, to withdraw the onefold member from the storing assembly and feed it back into the well, wherein the support surface of the channel is substantially horizontal and the retaining elements are substantially vertical, wherein:

The storing assembly comprises:

c. an upright support member carrying a rotatable sleeve;

d. at least one collar member, formed of a plurality of pivotally connected segments, at least one segment affixed to the sleeve, the remaining segments being movable from a locked position embracing the sleeve to a substantially linear transport position; and

e. a plurality of outwardly extending, substantially horizontal, radial struts pivotally mounted at their inner ends on the collar member, said struts carrying the circular channel adjacent their outer ends and being convertible from a fixed, radial operating position to a transport position wherein they are closely packed together in parallel formation on the linearly aligned collar segments.

4. The combination of claim **1** wherein the member comprises a metal sucker rod string.

5. In combination:

a substantially rigid onefold metal member adapted to be disposed in a well;

an opposed endless track pulling means adapted to engage and pull the member out of the well, to feed it to a storage means and to withdraw it from the storage means and run it back into the well; and a

freely rotatable reel storage means of a diameter which is adapted to form the member fed to it into a coil of a predetermined diameter and to store it in that form without the member being stressed beyond its 0.2 percent offset yield wherein:

the freely rotatable reel is powered by the member being fed thereto.