

April 13, 1965

R. N. KNIGHTS

3,177,944

RACKING MECHANISM FOR EARTH BORING EQUIPMENT

Filed June 1, 1960

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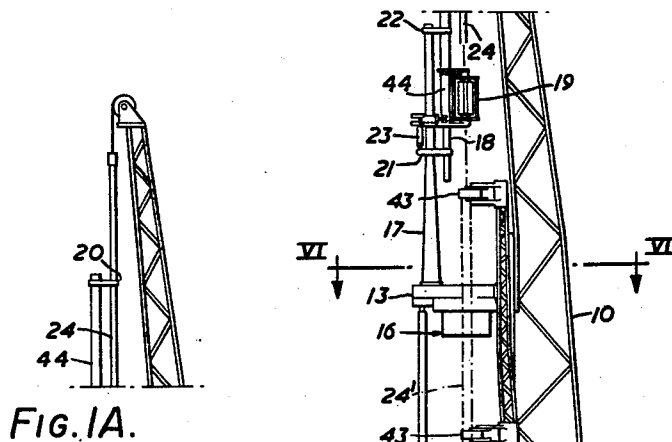


FIG. 1A.

FIG. 1.

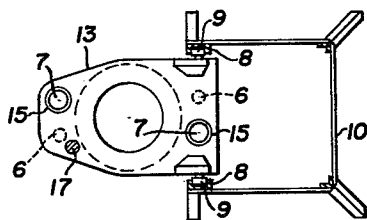
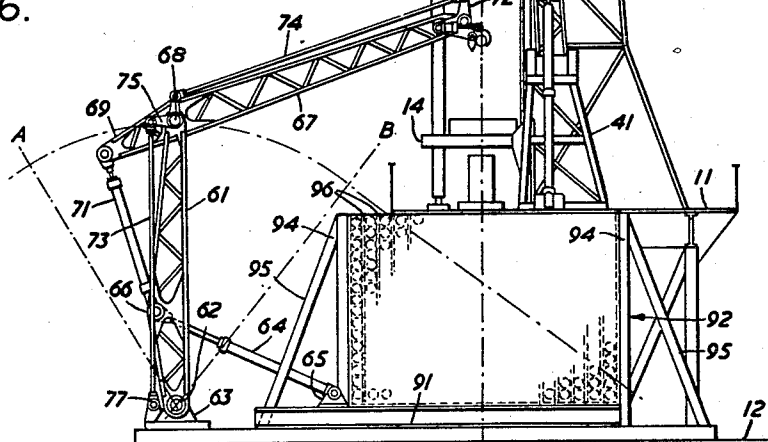


FIG. 6.



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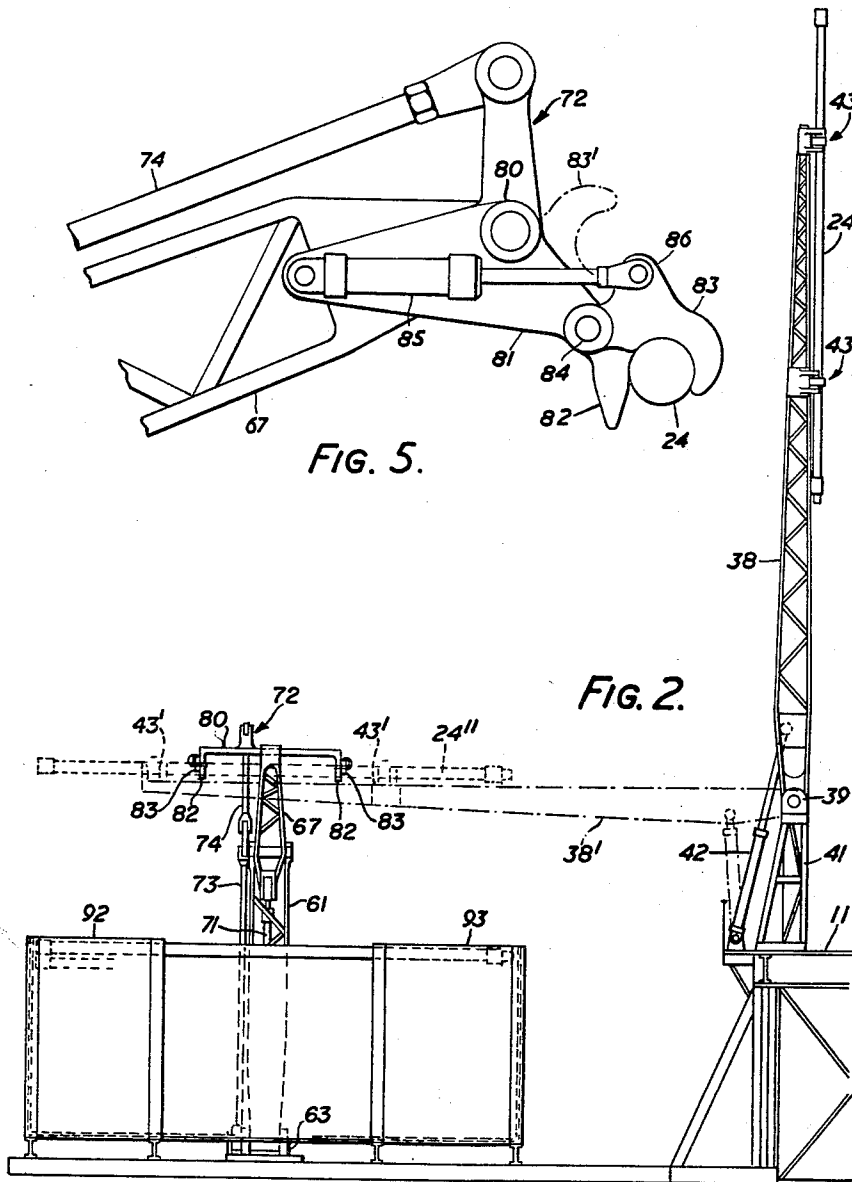
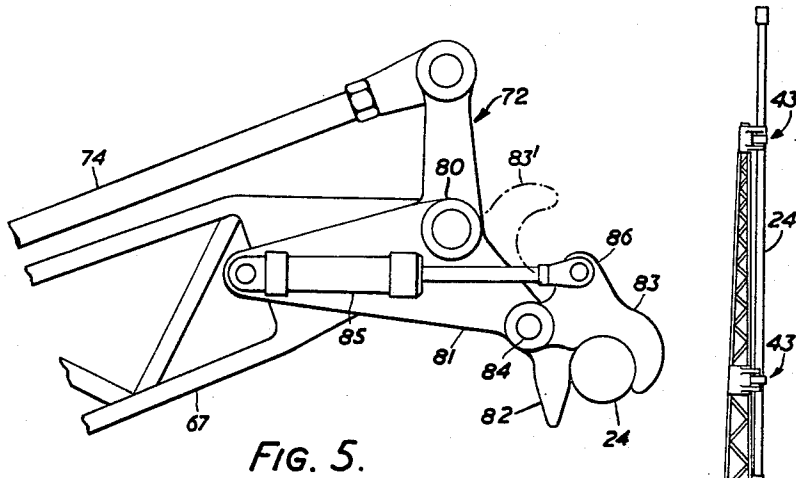
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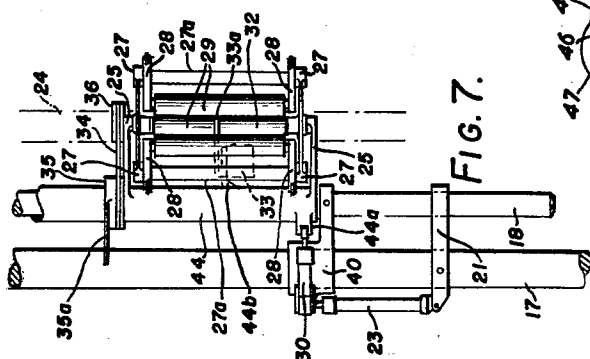
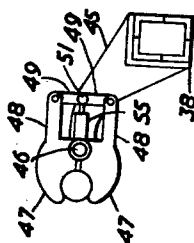
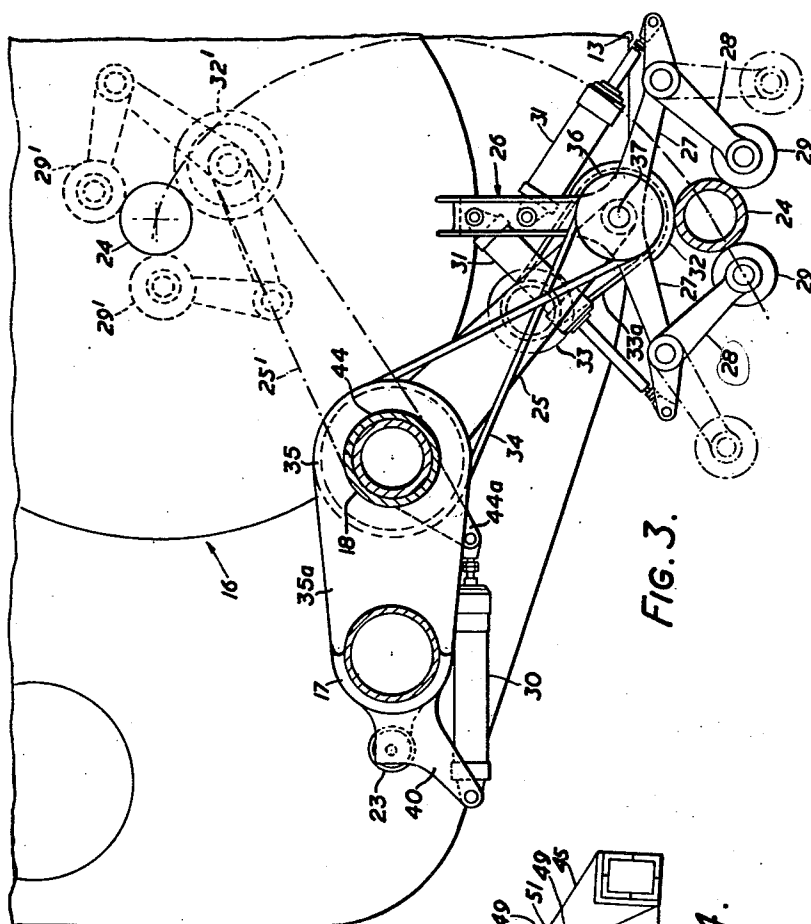
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RACKING MECHANISM FOR EARTH BORING EQUIPMENT

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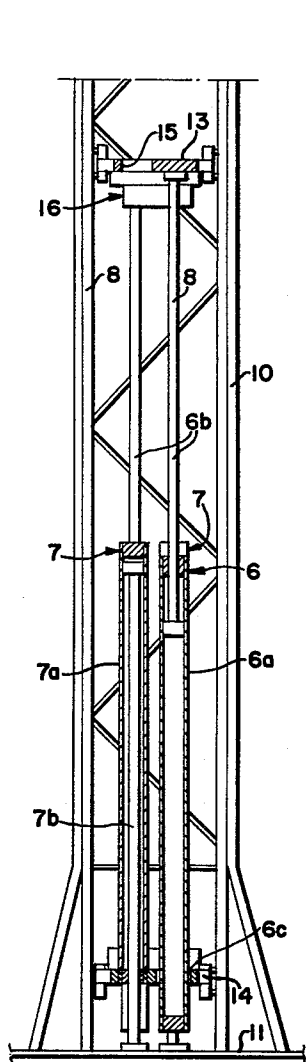


FIG. 8.

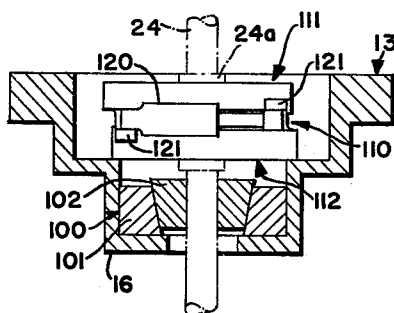


FIG. 10.

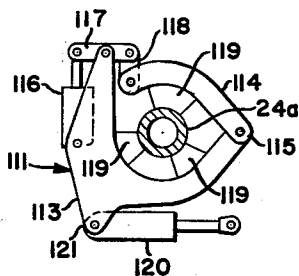


FIG. 11.

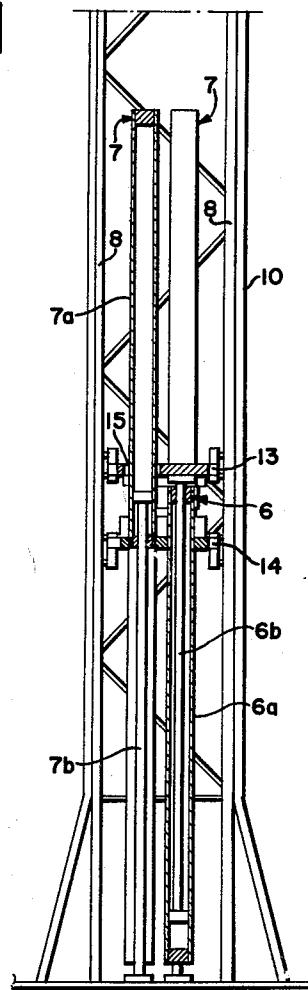


FIG. 9.

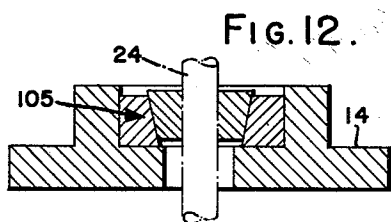


FIG. 12.

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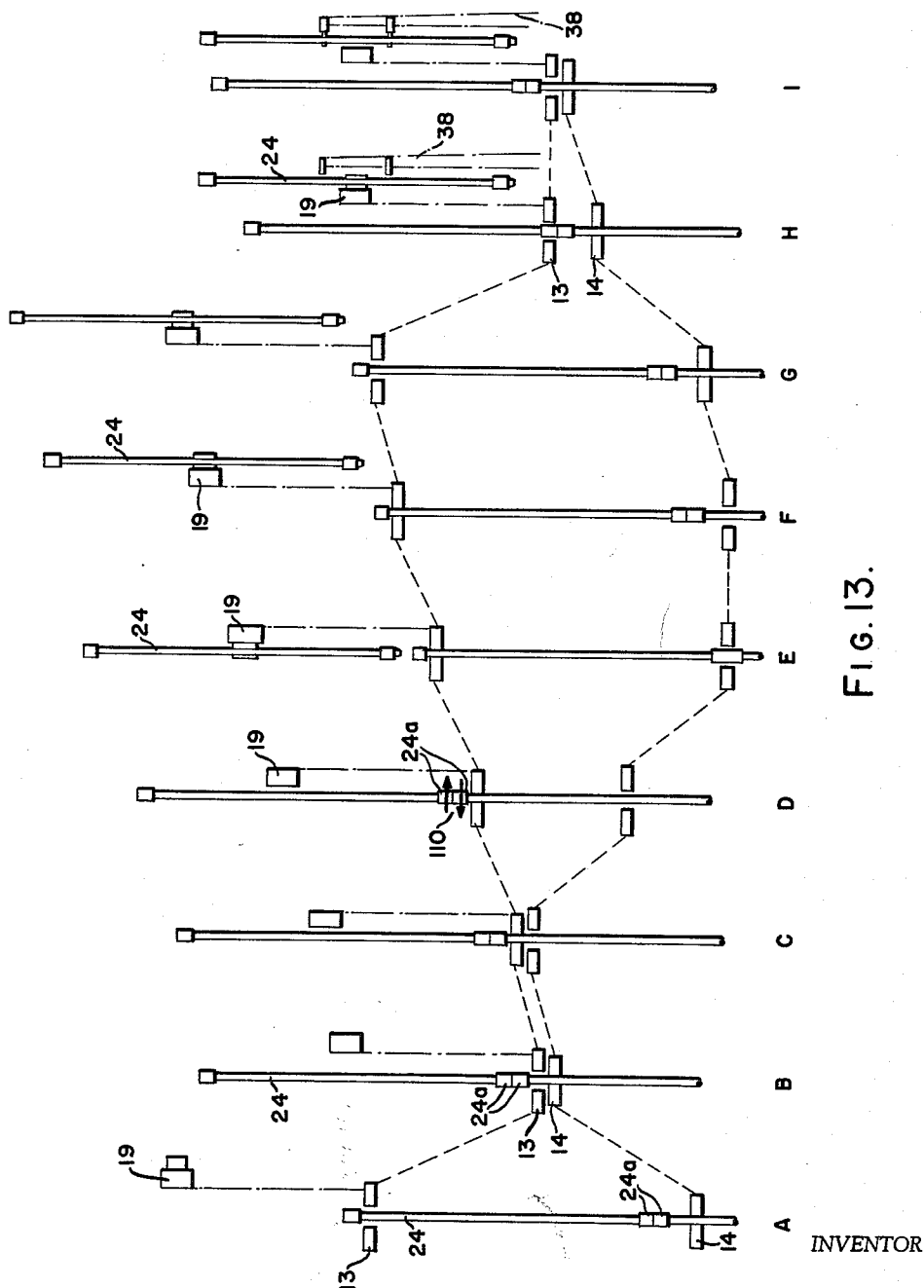
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RACKING MECHANISM FOR EARTH BORING EQUIPMENT

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5 Sheets-Sheet 5



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3,177,944

RACKING MECHANISM FOR EARTH BORING EQUIPMENT

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Filed June 1, 1960, Ser. No. 33,158

Claims priority, application Great Britain, June 2, 1959, 18,861/59

6 Claims. (Cl. 166—77.5)

This invention relates to earth boring equipment comprising a derrick having power-operated means for withdrawing or running in a string of drill pipe. The invention is particularly concerned with equipment for deep boring wherein a large number of pipe lengths have to be unscrewed and stored as the drill string is withdrawn, or taken from storage and screwed on to the string when the latter is run in.

According to previous proposals the pipe lengths may either be stacked in the derrick to one side of the drill string, or stored at the base of the derrick. Such arrangement, however, may seriously encumber the clear working space in and around the derrick when handling the large number of pipe lengths which are required in drilling to great depths.

The present invention provides for horizontal storage of pipe lengths to one side of and clear of the derrick by means of a transport arm which is pivoted towards the base of the derrick for swinging movement in a vertical plane, the outer end of the arm working between a substantially vertical position in which it can accept a pipe lengths from, or deliver a pipe length to, a station in the derrick, and a substantially horizontal position in which the arm can deliver a pipe length to, or accept a pipe length from, a station associated with storage means at one side of the derrick.

The storage means may comprise a rack structure wherein the individual pipe lengths are stored horizontally, and a racking member which can enter into co-operation with the transport arm at the latter station, the racking member being arranged to move pipe lengths one at a time, in either direction, between the said latter station and the several positions in the rack structure wherein the pipe lengths are stored.

The rack structure in which the pipe lengths are stored horizontally preferably has open ends giving free access to the screw-threaded pipe ends for inspection purposes.

A drilling derrick and associated racking mechanism constructed to operate in accordance with the invention is illustrated in the accompanying drawings, of which:

FIGURE 1 is a side elevation of the drilling derrick except for its upper part, and racking mechanism;

FIGURE 1A is a side elevation of the upper part of the drilling derrick;

FIGURE 2 is a front elevation of the racking mechanism alone seen from the right hand side of FIGURE 1;

FIGURE 3 is an enlarged plan view of the pipe spin-off mechanism seen on the section line III—III of FIGURE 1;

FIGURE 4 is an enlarged detail view of the pipe gripping jaws mounted on the transport arm as seen from below in FIGURE 1; and

FIGURE 5 is an enlarged detail of the free end of the racking arm shown in FIGURE 1;

FIGURE 6 is a sectional view on the line VI—VI of FIGURE 1;

FIGURE 7 is an enlarged elevation view of the spin-off mechanism in the upper part of FIGURE 1;

FIGURE 8 is a front elevation, i.e. from the left-hand side in FIGURE 1 but on a larger scale, of part of the drilling derrick having lift platforms mounted thereon together with telescopic hydraulic jacks for operating

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same, the jacks on the near side of the structure being shown in section;

FIGURE 9 is a front elevation similar to FIGURE 8 but with the lift platforms and hydraulic jacks in different positions;

FIGURE 10 is a diagrammatic drawing of the upper lift platform on a larger scale than in FIGURES 8 and 9, and in section to show mechanism housed therein;

FIGURE 11 is a plan view of a detail of FIGURE 10;

FIGURE 12 is a diagrammatic drawing of the lower lift platform on a larger scale than in FIGURES 8 and 9, and in section to show mechanism housed therein; and

FIGURE 13 is a sequence diagram relating to operation of the lift mechanism and spin-off mechanism.

The drilling derrick 10, FIGURE 1, comprises a lattice structure upstanding from a base platform 11 which itself is supported above the ground 12 by a suitable base structure. The derrick supports at its front a pair of opposed vertical channel members 8 which form guideways for upper and lower lift platforms 13 and 14, see also FIGURES 8 and 9. Each platform as exemplified by platform 13 in FIGURE 6 has rollers 9 on opposite sides engaged in the guideways 8 and arranged to maintain the platform horizontal during vertical guided movement. The lift platforms 13 and 14 are movable independently along a common vertical axis by means of telescopic hydraulic jacks. One pair of hydraulic jacks 6 has cylinders 6a upstanding from the base platform 11 and piston rods 6b fixed to the upper lift platform 13. Each cylinder 6a extends with clearance through a hole 6c in the lower lift platform 14. Another pair of hydraulic jacks 7 have piston rods 7b upstanding from the base platform and cylinders 7a whose lower ends are fixed to the lower lift platform 14. The upper lift platform 13 has a pair of holes 15 in it through each of which the respective cylinder 7a can extend with clearance when the lift platforms 13 and 14 approach one another closely.

The arrangement of hydraulic jacks 6 and 7 in FIGURES 8 and 9 will be better understood with reference to FIGURE 6 where it is seen that the axes of the jacks intersect a transverse plane at the corners of a rectangle, in which the jacks of each pair occupy diagonal positions. The jacks of each pair are diametrically opposed with respect to the axes of the drill pipe string.

The upper lift platform 13 is in part formed as a housing 16 for slips mechanism 100 which can support the weight of the drill pipe string, and for a mechanism 110 which can make and break the tool joints between the lengths of drill pipe. The slips mechanism 100 is of generally known kind comprising outer members 101 with inclined inner surfaces along which inner wedge members 102 are movable to grip or to release a pipe length 24. The mechanism 100 is illustrated diagrammatically in FIGURE 10 but a more developed mechanism suitable for the purpose is described in U.S. Patent No. 3,029,488 of Richard N. Knights. The mechanism 110 comprises essentially upper and lower pipe gripping assemblies 111 and 112 respectively. The upper assembly 111 shown in FIGURE 11 is seen to comprise two jaws 113 and 114 pivoted together at 115. The jaws can be closed together or opened apart by a telescopic jack 116 which is carried by the jaw 113 and which acts through a lever 117 and link 118 to move the jaw 114. The jaws 113 and 114 carry gripping blocks 119 which can thus be closed on to, or released from a connector 24a at the end of one drill pipe length 24. The pipe gripping assembly 112 is similar to the assembly 111 and in position to grip the connector of the adjoining drill pipe length. The pipe gripping assembly 112 is inverted with respect to the assembly 111 and a telescopic jack 120 is interposed between lugs 121 on the larger jaws 113 of the respective assemblies 111, 112. The jack 120 lies in a transverse

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plane and can be extended or contracted to effect relative turning movement of the assemblies 111, 112 about the axis of the drill pipe string for making or breaking the usual screw joint between the drill pipe connectors. Such mechanism is described in more detail in the U.S. Patent No. 3,041,901 of Richard N. Knights.

The lower lift platform 14 houses slips mechanism 105 similar to the slips mechanism 100.

The telescopic jacks 6 and 7 are operated by conventional hydraulic means which are not shown for the sake of simplicity of illustration. The strokes of the jacks are controlled manually or otherwise so as to enable the upper lift platform 13, when lowered, and the lower lift platform 14, when raised, to be in proximity, see FIGURE 9, and to be movable together over a small part of the strokes of each pair of jacks 6 and 7 so that the support of the drill pipe string can be transferred from the slips mechanism 105 to the slips mechanism 100 while both lift platforms 13 and 14 are in motion. When the drill pipe string is supported by the slips mechanism 100 of the upper lift platform 13, the make and break mechanism 110 can be operated to loosen the screw joint between adjacent connectors 24a so that a length of pipe projecting above the upper lift platform 13 can be fully unscrewed by spin-off mechanism which will be described. Conversely, when running in a string of drill pipe the make and break mechanism can be operated to tighten the screw joint between the added length of drill pipe and the drill pipe string, after which the support of the latter can be transferred from the slips mechanism 100 of the upper lift platform 13 to the slips mechanism 105 of the lower lift platform 14 while the platform 13 is moving over the end part of its downward stroke and the platform 14 is moving over the beginning part of its downward stroke.

A pillar 17 upstanding from the upper lift platform 13, shown in FIGURES 1, 3, 6 and 7 but omitted from FIGURES 8 and 9, provides a mounting for a tubular column 18 on which spin-off mechanism 19 is mounted for operating co-axially with and above the make and break mechanism 110. Two brackets 21 and 22 fixed to the pillar 17 provide guide bearings for movement of the column 18 in a vertical direction, while a hydraulic jack 23 anchored to the bracket 21 acts vertically against a movable bracket 40 which is mounted on the pillar 17, see FIGURE 7. The jack 23 can act through the movable bracket 40 upon the column 18 and spin-off mechanism 19 in order to lift a pipe length 24 clear of the string of drill pipe and the upper lift platform 13 as it is unscrewed. The upper portion of the pipe 24 is steadied by releasable locating jaws 20 at the upper end of a tube 44 which is mounted on the column 18, these jaws being provided merely to prevent the upper portion of the drill pipe 24 from whipping when it is rotated by the spin-off mechanism.

The spin-off mechanism shown in FIGURES 3 and 7 comprises a pair of arms 25 fixed to the tube 44 which can turn on the column 18. A hydraulic jack 30 attached to the movable bracket 40 acts horizontally against an arm 44a fixed to the tube 44 to swing the arms 25 between extreme positions of which one is shown in full lines and the other is in chain dot lines at 25'. These extreme positions correspond to the position at the side of the drill rig at which a drill pipe may be handed over to or accepted from the transfer arm (to be described), and to the central position at which the drill pipe may be accepted from or handed over to the string of drill pipe. It is to be understood that the operation of the spin-off mechanism is reversible for joining of pipe lengths to the drill string prior to tightening these joints by the make and break mechanism 110. The swinging arms 25 carry at their outer ends a pipe gripping roller assembly 26 which is itself rotatable bodily about a vertical axis 37 in the outer ends of the arms 25. The assembly 26 has upper and lower sets of divergent arms 27 in which are

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fixed the ends of vertical posts 27a. Upper and lower levers 28 pivoted on each post 27a carry the ends of a pipe-engaging roller 29. Two such rollers 29 carried by the respective levers 28 may be closed towards each other or separated by means of two hydraulic jacks 31 which are anchored to the assembly 26 and act upon the respective levers 28. The two rollers 29 are idling rollers free to turn about vertical axes, while a power driven spin-off roller 32 is mounted to turn about the vertical axis 37 at the outer end of the arms 25. The spin-off roller 32 is driven through a transmission belt 33a by a hydraulic motor 33, FIGURES 3 and 7, which is fixed to a bracket 44b projecting from the tube 44.

The assembly 26 with its divergent arms 27, levers 28 and hydraulic jacks 31 is rotatable in the outer ends of the swinging arms 25 by a belt or chain 34 which passes around a pulley 35 mounted on the tube 44 and around a pulley 36 which is fast with the assembly 26. The pulley 35 is prevented from turning with respect to the column 18 by a laterally projecting fork 35a which engages the pillar 17. The lengths of the pulley belt 34 cross over between the pulleys 35 and 36 so that swinging the arms 25 causes the pulley 36 to turn in the same rotational sense. Swinging of the arms 25 by the hydraulic jack 30 in an anticlockwise direction from the full line position shown in FIGURE 3 therefore causes the belt 34 to impart an additional simultaneous anticlockwise motion to the assembly 26. This enables the assembly 26 to approach the pipe length 24 on the axis of the drill string with the rollers 29 passing on opposite sides thereof and the driving roller 32 moving laterally into direct engagement with it. When the assembly is swung towards the pipe length 24, the rollers 29 are held apart by the contraction of the jacks 31 following which the jacks 31 are extended causing the idler rollers 29 to grip the pipe length 24 against the driving roller 32.

The operation of the drilling derrick with the lift mechanism and spin-off mechanism will now be described with reference to the sequence diagram of FIGURE 13.

FIGURE 13 illustrates successive steps A-I at the commencement of pipe pulling in which the lifts 13 and 14 are illustrated diagrammatically as being engageable with or disengaged from the string of drill pipe. The spin-off mechanism 19 is shown associated with the upper lift 13, and the make and break mechanism 110 is indicated by arrows at stage D.

At stage A the lower lift 14 is closed on the drill pipe 24 below the connectors 24a and it is rising. Meanwhile the upper lift 13 is open and descends fully to await the approach of the lower lift 14 at stage B. Between stages B and C the lifts move together and lift 13 closes below the connectors 24a after which lift 14 opens so that the weight of the pipe string is transferred from the lower lift 14 to the upper lift 13. At stage C, lift 14 is at the end of its upward stroke and starts to descend while lift 13 continues to rise.

At stage D the make and break mechanism 110 is operated as previously described to loosen the screw joint between the connectors 24a, and thereafter the spin-off mechanism 19 is operated to unscrew the connectors 24a fully. The jack 23, FIGURE 7, is extended to lift the spin-off mechanism as the joint is unscrewed and to continue lifting the upper pipe length 24 relative to the drill string to the point, stage E, at which the upper pipe length 24 is well clear of the drill string and the upper lift 13. The jack 30 can then be contracted to swing the arms 25 and the spin-off mechanism 19 bodily away from the axis of the drill string to bring the unscrewed pipe length 24 to the side of the drilling derrick, stage F.

The open lower lift 14 has meanwhile descended and between stages F and G it rises at the same speed as the upper lift 13. Between these stages the lower lift 14 closes on the drill pipe string below the tool joint of the next succeeding pipe length, after which the upper lift 13 is opened prior to its descent.

At stage G the two lifts have undergone a complete cycle and returned to the original stage A, though the spin-off mechanism 19 now carries the unscrewed pipe length 24. At stage H the upper lift 13 has descended fully to await the upward approach of the lower lift 14, and during this waiting period when it is stationary the pipe length 24 is in position to be gripped by a transport arm 38 of racking mechanism, to be described, and then released from the spin-off mechanism 19 by contraction of the jacks 31.

It is to be understood that the sequence is reversible when running the drill string into a bore hole, whereby a pipe length 24 delivered by the transport arm 38 at stage I is spun on and tightened on the upper end of the drill pipe string between stages E and D as the drill pipe string is lowered.

The transport arm comprises a lattice girder 38 hinged at one end on a pin 39 which is carried by a mounting bracket 41 upstanding from the base platform 11. The transport arm 38 is swung in a vertical plane between the upright position shown in FIGURE 2 in full lines and the horizontal position 38' shown in chain dot lines by a hydraulic jack 42. The outer portion of the arm 38 carries two spaced pipe grips 43 the construction of which is diagrammatically shown in FIGURE 4. A bracket 45 extending from the arm 38 carries a hinge pin 46 for two jaws 47 having arcuate recesses shaped to engage the drill pipe. The two jaws 47 have integral tails 48 which extend rearwardly and have a pair of toggle links 49 connected between them. The centre pivot 51 of the toggle linkage has one member of a hydraulic jack 55 connected to it while the other member of the hydraulic jack is anchored to the hinge pin 46. If the operating jack 55 is extended, the toggle formed by the links 49 breaks thus drawing the tails 48 together and opening the jaws 47. Contraction of the jack 55 turns the toggle links 49 into line thus closing the jaws 47 together. If the links 49 are slightly over top dead centre in the contracted position of the jack 55 the jaws 47 will remain closed in the event of a hydraulic failure thus minimizing the risk of a pipe length coming adrift from the transport arm 38.

The pipe grips 43 are arranged to take over the drill pipe 24 from the spin-off mechanism 19 in the lowest position of the lift platform 13 and the transport arm 38 is thereupon caused to swing downwardly to the horizontal position 38'. At this point the pipe length now at 24' in a station associated with storage means at which the pipe length is arranged to be taken over by a power-operated racking member for depositing it in a rack structure. The racking member comprises a lower arm 61 mounted by a pivot 62 to a base bracket 63. A hydraulic jack 64 interposed between a ground anchorage 65 and an intermediate point 66 on the inner arm 61 controls swinging movement of the latter in a vertical plane between the radii A and B. An upper arm 67 carried by pivot pin 68 on the upper end of the lower arm 61, has a tail portion 69 coupled to a hydraulic jack 71 which is anchored on the pivot pin 66. The jack 71 thus controls movement of the outer arm 67 in a vertical plane.

The upper arm 67 carries a pipe gripping mechanism 72 which is kept in a constant attitude irrespective of the positions of the arms 61 and 67 by means of two parallelogram linkages of which the arms 61 and 67 respectively form two of the long sides. The other long sides are provided by links 73 and 74 whose effective lengths are equal to those of the arms 61 and 67, these lengths being interconnected by a bell crank lever 75. The lower end of the link 73 is carried by a pivot 77 on the base bracket 63 while the outer end of the link 74 is connected by a pivot 78 to the pipe gripping mechanism 72.

The latter mechanism shown on a larger scale in FIGURE 5 comprises a plate 81 having a fixed jaw 82 and a moving jaw 83 mounted thereon by a pivot 84. A hydraulic jack 85 is pivotally interposed between the plate 81 and a lug 86 on the jaw 83 so as to turn the latter be-

tween the full line position shown in the drawing and the open position shown in chain dot line at 83'. It is to be observed that in the open position, the moving jaw 83 is swung back far enough to allow a pipe length 24 carried by the transport arm to move vertically downwards past the open jaw 83' into a position where the latter can be closed on the pipe length by the jack 85. The jaws 82 and 83 and the jack 85 are duplicated so as to support the pipe length at spaced points between the pipe grips 43 on the transport arm. The fixed jaws 82 are rigidly connected by a torque tube 80 which can turn in the outer end of the arm 67.

By control of the hydraulic jacks 64 and 71 the pipe gripping mechanism 72 on the upper arm 67 can be brought to any position within the confines of the rack structure now to be described. This structure mounted on a base 91 comprises two end sections 92 and 93 each having side walls 94 supported by bracing struts 95. A plurality of vertical divisions 96 which are open at the top are fixed in the end sections 92 and 93 at a spacing which allows the pipe lengths to be stacked singly between them. The end sections 92 and 93 are spaced apart wider than the spacing between the two sets of jaws 82 and 83 on the arm 67 so that the latter can move freely to any position to deposit a pipe in the rack structure or to take one away. The pipe lengths are deposited in the rack structure in horizontal layers and taken away in like manner.

When running the string of drill pipe into a bore hole prior to continued drilling, the racking member formed by the arms 61, 67 and their actuating jacks together with the associated pipe gripping mechanism, is operable in reverse sequence to pick up pipe lengths one at a time and transfer them to the transport arm 38 in the horizontal position 38' of the latter as seen in FIGURE 2.

The transport arm 38 is of course reversible in its operation by the jack 42 to raise pipe lengths 24 one at a time into the vertical position shown at which the pipe length can be taken over by the spin-off mechanism 13, between stages I and H in FIGURE 13.

I claim as my invention:

1. In combination, a derrick; a lift mechanism mounted in the derrick to be raised and lowered in a vertical path, pipe gripping means on the lift mechanism to engage and support a string of pipe lengths in an upright disposition, means for operating the lift mechanism and the pipe gripping means, to run in and pull the pipe string from and to an elevated upright position over the ground, respectively; a joiner mechanism mounted on and raised and lowered with the lift mechanism, to attach and detach the pipe lengths to and from the pipe string, means for operating the joiner mechanism, to add and remove pipe lengths to and from the string in the elevated position; a first pipe transport mechanism mounted on and raised and lowered with the lift mechanism, to be moved back and forth in a transverse path adjacent the elevated position, second pipe gripping means on the pipe transport mechanism to engage and support a pipe length in an upright disposition, means for operating the pipe transport mechanism and the second pipe gripping means, to feed in and withdraw the pipe lengths from and to an outlying upright position offset from the string, respectively; a second pipe transport mechanism pivotally mounted adjacent one side of the derrick, to be swung up and down in a vertical plane adjacent the outlying position, third pipe gripping means on the second pipe transport mechanism to engage and support a pipe length in an upright disposition, and means for operating the second pipe transport mechanism and the third pipe gripping means, to feed up and lower the pipe lengths from and to a substantially horizontal handling position on the side of the derrick, respectively.

2. The combination according to claim 1 further comprising an articulated third pipe transport mechanism mounted adjacent the side of the derrick, to have one end thereof moved up and down, and to and fro, in a vertical plane adjacent the handling position, fourth pipe grip-

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ping means pivotally mounted on the end of the third pipe transport mechanism, to engage and support a pipe length in a substantially horizontal disposition, means for operating the third pipe transport mechanism and the fourth pipe gripping means, to unload and load the pipe lengths from and into a racked position on the side of the derrick, respectively, and means interconnecting the fourth pipe gripping means with the ground, to maintain the pipe lengths in a constant attitude with respect to the latter, during the operation of the third pipe transport mechanism.

3. The combination according to claim 1 wherein the second pipe transport mechanism includes a transport arm which is pivotally mounted on the side of the derrick to be swung up and down in a vertical plane adjacent the outlying position.

4. The combination according to claim 1 wherein the first pipe transport mechanism is pivotally mounted on the lift mechanism to be swung back and forth in a transverse path adjacent the elevated position.

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5. The combination according to claim 4 wherein the first pipe transport mechanism includes a spin-off mechanism that cooperates with the second pipe gripping means.

6. The combination according to claim 5 wherein the joiner mechanism also includes a make and break mechanism on the lift mechanism.

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