

June 7, 1960

W. H. SPIRI

2,939,683

POWER SLIP ASSEMBLY

Filed Dec. 10, 1956

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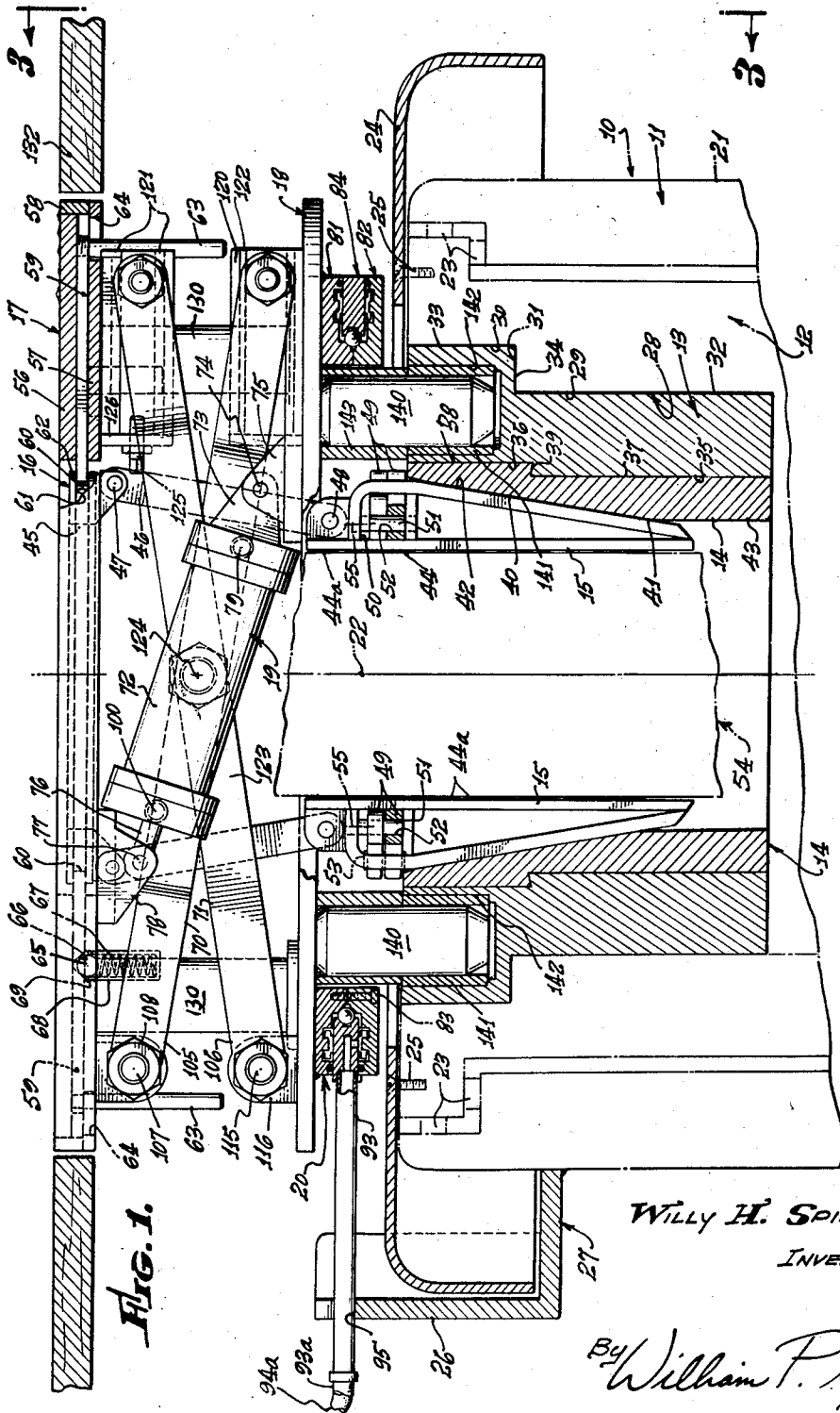


FIG. 1.

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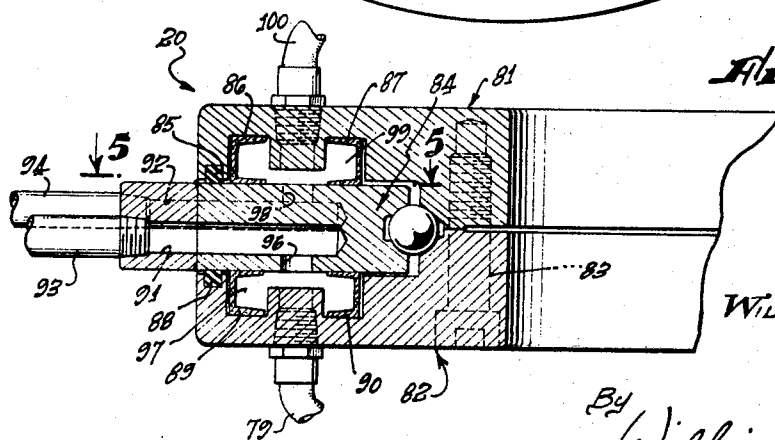
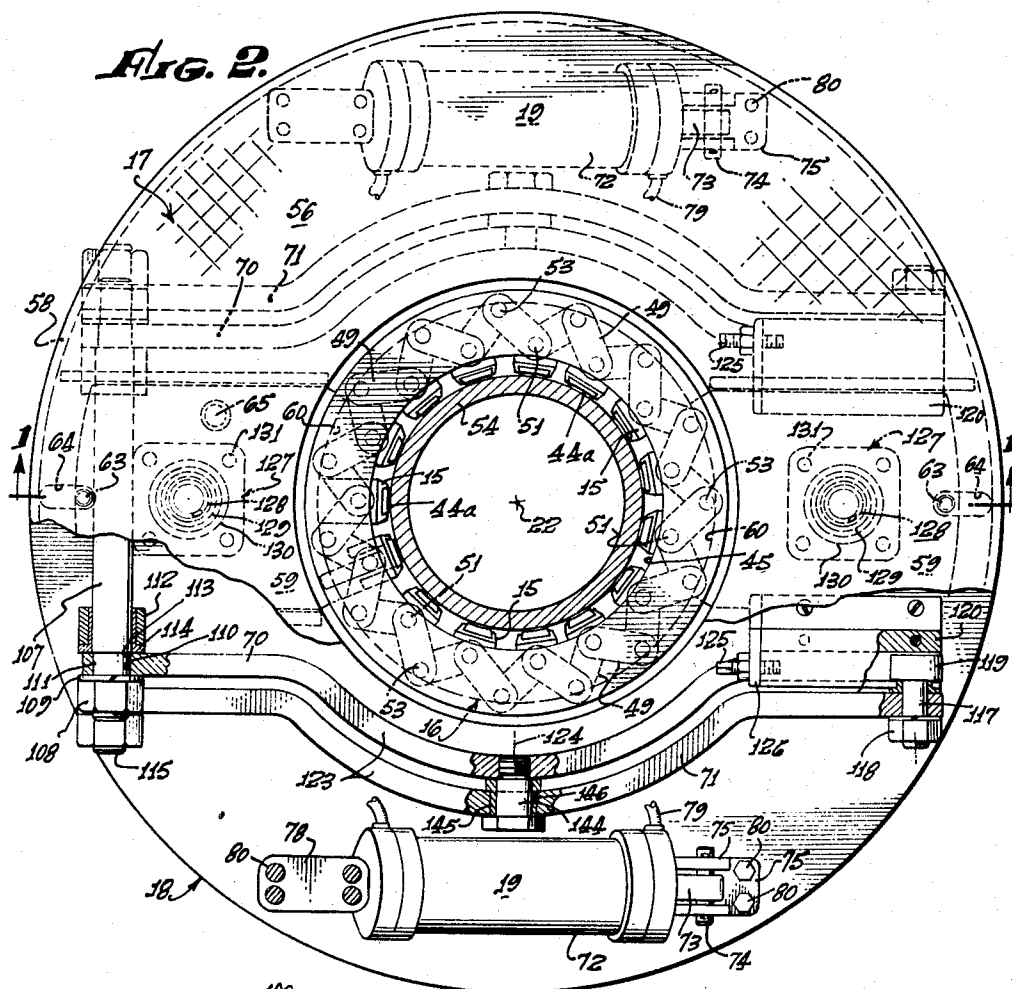
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3 Sheets-Sheet 2



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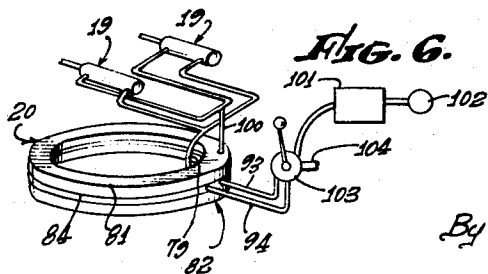
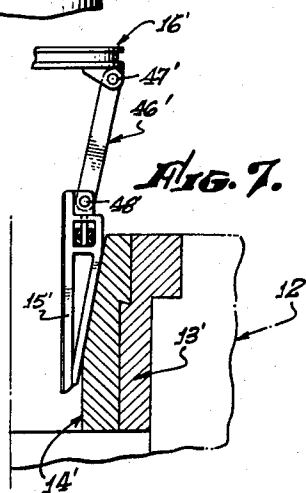
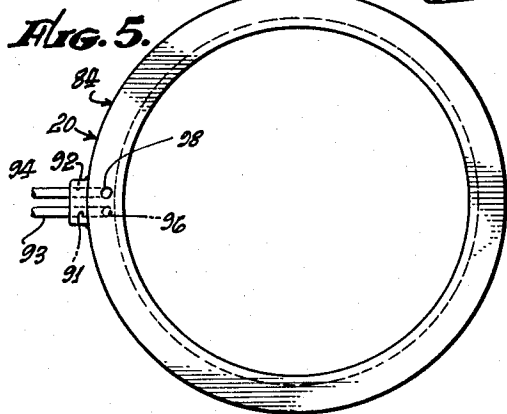
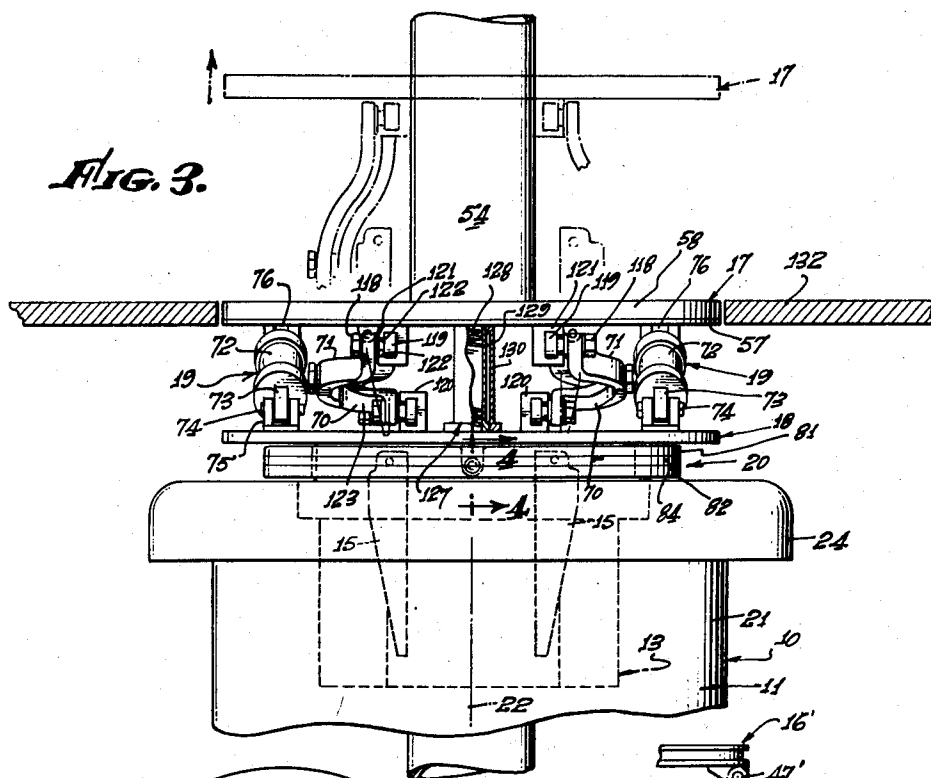
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POWER SLIP ASSEMBLY

Filed Dec. 10, 1956

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2,939,683

POWER SLIP ASSEMBLY

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Filed Dec. 10, 1956, Ser. No. 627,316

14 Claims. (Cl. 255—23)

This invention relates to improved power actuated slip assemblies for use in the rotary table of a well drilling rig.

A conventional power slip assembly includes a number of slips for gripping and supporting a well string, together with means for power actuating the slips vertically between active lowered positions and elevated inactive positions. Ordinarily, the slips are mounted to a stationary support structure which projects upwardly at a side of the rotary table and which includes a suitable power piston or other power unit for raising and lowering the slips. One difficulty encountered, however, has been that of accurately centering the slips when thus supported, and of always maintaining the proper centering of the slips under actual conditions of use.

A major object of the present invention is to provide an improved power slip assembly in which the slips are centered much more accurately and effectively than has been possible in prior arrangements. To achieve this purpose, the slip support structure is mounted to turn with the rotating portion of the rotary table, rather than being attached to the outer stationary portion of the table, to thus always maintain proper centering of the slips with respect to the rotating parts. Preferably, the slip support structure is mounted to the master bushing which is located in the rotary table.

Structurally, an assembly embodying the invention may include a support section which turns with the rotary table, and a slip carrier section to which the slips are mounted and which is vertically actuatable relative to the support section to move the slips between active and inactive positions.

Desirably, the power unit for actuating the carrier section and slips is also rotatable with the table and the other sections of the device, typically being one or more power cylinders and pistons interposed vertically between the two sections. Actuating pressure fluid, such as compressed air, may be fed to the power units through a pair of communicating feed rings, one of which turns with the table and the other of which is non-rotating.

The above and other features and objects of the present invention will be better understood from the following detailed description of the typical embodiment illustrated in the accompanying drawings in which:

Fig. 1 is a vertical axial section through a well drilling rotary table and power slip assembly constructed in accordance with the invention, the view being taken primarily on line 1—1 of Fig. 2, but certain parts of the apparatus near the top of Fig. 1 being shown in elevation;

Fig. 2 is a plan view of the apparatus shown in Fig. 1;

Fig. 3 is a reduced scale view taken on line 3—3 of Fig. 1;

Fig. 4 is an enlarged fragmentary vertical section through the air supply rings of Fig. 1;

Fig. 5 is a reduced scale horizontal section taken on line 5—5 of Fig. 4;

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Fig. 6 is a diagrammatic representation of the pressure fluid system of the apparatus; and

Fig. 7 is a fragmentary vertical section showing a slightly variational form of the invention.

Referring first to Figs. 1 and 3, I have shown at 10 a conventional well-drilling rotary table structure including the usual outer stationary section 11, and an inner relatively rotatable power-driven section 12. Within the rotating portion 12 of the rotary table, there is mounted a master bushing 13, containing a pair of slip bowl segments 14 within which a number of slip elements 15 are received. These slip elements 15 are movably carried by a supporting ring 16, which is in turn removably carried by a ring 17. Ring 17 is vertically actuatable relative to a body 18, by means of a pair of fluid-actuated piston and cylinder mechanisms 19 to which compressed air or other actuating fluid is fed through a feed ring structure 20. The body 18 is mounted to master bushing 13 for rotation therewith, so that all of the parts carried by body 18, including rings 16 and 17 and slips 15, may turn with the master bushing and the rotary table.

The outer stationary portion 11 of the rotary table 10 is mounted in any suitable manner to a supporting frame structure. This outer section 11 includes an annular portion 21 within which the smaller diameter annular rotating section 12 of the table is mounted for relative rotation about the vertical axis 22 of the apparatus. The rotary support of inner section 12 relative to outer section 11 is effected by means of any suitable bearing structure, typically including two annular series of roller bearings represented at 23 in Fig. 1. The section 12 of the rotary table is power-driven rotatably about axis 22 by any suitable drive mechanism (not shown). The inner rotating section may carry an annular outwardly and then downwardly extending element 24, suitably attached to section 12, as by screws 25. The outer section 11 may include a bracket member 27 at one side, welded to element 12 and projecting first outwardly therefrom, and then upwardly at 26.

The inner rotating section 12 of the rotary table contains an opening 28 extending vertically therethrough, and having a lower cylindrical portion, and an upper non-circular and preferably square portion 30. This upper portion 30 is of a size to project laterally beyond the diameter of lower cylindrical portion 29 of opening 28, to provide an upwardly facing shoulder on which the master bushing 13 is supported.

The master bushing 13 is generally annular in configuration and is preferably formed of a single piece of rigid metal extending continuously entirely about the circular extent of bushing 13. Externally, bushing 13 has a lower cylindrical portion 32 and an upper non-circular and preferably square portion 33, with these surfaces 32 and 33 and an intermediate shoulder 34 being shaped the same as surfaces 29, 30 and 31, respectively, of section 12 of the rotary table, to engage those surfaces in a manner positively supporting the bushing 13 in the rotary table, and effectively driving the bushing with the rotary table about axis 22.

The ring 18 is a flat horizontally extending annular rigid plate centered about axis 22 and located above bushing 13. This ring is rotatably keyed to and driven by bushing 13 by means of several (preferably four) circularly spaced cylindrical pins 140, which project downwardly from ring 18 into a number of cylindrical sleeves 141 contained within recesses 142 in bushing 13. The pins 140 are rigidly welded or otherwise attached to ring 18, as are four sleeves 143 which are disposed about upper positions of the pins. The lower sleeves 141 are rigidly welded or otherwise secured to bushing 13. The

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engagement of the lower ends of sleeves 143 with the upper surfaces of bushing 13 and sleeves 141 positively supports the ring 18 in the Fig. 1 position relative to the rotary table and bushing, while at the same time rotatively keying ring 18 to the bushing for rotation therewith. As will be apparent, ring 18 and the carried parts may all be detached from the rotary table by merely lifting ring 18 upwardly so that pins 140 will be withdrawn from recesses 142 and their liner sleeves 141. The four recesses 142 may be located within the four corners of the upper square portion 33 of bushing 13.

Internally, the master bushing 13 has a lower inwardly facing cylindrical surface 35 and an upper inwardly facing cylindrical surface 36 of somewhat increased diameter. The slip bowl structure received within bushing 13 may in some instances consist of a single annular body, but preferably is formed of two semi-circular and complementary segments 14, having outer reduced diameter cylindrical surfaces 37 engaging surface 35 of bushing 13, and having upper increased diameter cylindrical surfaces 38 engaging surface 36 of bushing 13. Between these surfaces 37 and 38, the bushing 13 and the slip bowl segments 14 have annular shoulders 39 which are interengageable to positively support the slip bowl segments within bushing 13.

The inner surfaces of slip bowl segments 14 have upper portions 40 which taper progressively downwardly to a reduced diameter at 41, the taper of these surfaces being preferably frusto-conical, as will be apparent from Fig. 1. These surfaces 40 engage the outer correspondingly tapering surfaces 42 of a series of circularly spaced slips 15, so that downward movement of the slips 15 relative to slip bowl segments 14 and the rotary table causes the slips to be displaced radially inwardly against a drill pipe or other pipe extending vertically through the apparatus along axis 22. Beneath the downwardly tapering surfaces 40 of segments 14, these segments may have inner cylindrical surfaces 43.

Each of the slips 15 has an inner gripping surface 44 which is irregularized in some manner to effectively grip and support a well pipe engaged by the slips. To form this surface, each slip 15 may carry a vertical series of gripping elements 44a, whose inner edges function as the irregularities for gripping the pipe. The gripping edges of the various slip surfaces 44 of each of the slips lie essentially in a common vertical plane, to all simultaneously engage the pipe, and these edges may curve slightly about axis 22, if desired, to conform somewhat to the curvature of the outer surface of the pipe. The various slips 15 are of rather small extent circularly about axis 22 (see Fig. 2) so that a large number of the slips may be provided to engage the pipe at a number of different locations about its circular extent. Preferably, I utilize as many of the slips 15 as can practically be grouped around the size of pipe for which the device is designed.

As previously mentioned, all of the slips 15 are supported by a common annular ring 16. This ring 16 is spaced above the slips, and contains an inner opening 45 centered about axis 22 for passing the well pipe vertically through ring 16. The slips are individually suspended from ring 16 by means of a number of links 46, each of which is pivotally attached at 47 to ring 16, and is pivotally attached at a lower end 48 to the associated slip 15. These links 46 allow slips 15 to move radially toward and away from axis 22, in correspondence with the vertical movement of the slips relative to the wedge surfaces 40 of segments 14. The pivotal connections at 47 and 48 are of course such as to maintain links 46 and slips 15 in a desired orientation relative to ring 16 so that the inner gripping surfaces 44 of the slips always face directly inwardly towards axis 22.

The proper positioning of each slip relative to the other slips in all conditions of the apparatus is further controlled by the provision of a series of links 49 which movably interconnect adjacent slips. For connection to these

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links, each slip contains a recess 50 near its upper end, within which there is mounted a vertical shaft or pin 51, fixed relative to the slip, and extending through openings 52 in a pair of the links 49. These two links 49 connected to one of the slips 15 extend in generally opposite circular directions from that slip, for attachment at their ends to a pair of similar links connected to adjacent slips. The connection between these links is effected by means of vertical pins or shafts 53 (see Fig. 2), which extend through openings in the ends of the links. Thus, each pair of adjacent slips 15 are connected together by a pair of the links 49, which are pivoted respectively to the two slips, and are also pivotally connected at their opposite ends to each other. This type of linkage freely allows movement of the slips radially toward and away from axis 22, but tends to retain all of the slips at essentially the same distance from the axis in a particular setting of the apparatus, and also very effectively holds all of the slips in properly oriented positions in which their inner irregularized surfaces 44 extend vertically as seen in Fig. 1 for proper engagement with the well pipe 54. This is true in part because the pivotal connections at 51-52 connect each of the links 49 to an associated slip 15 for pivotal movement about an axis 55 which is fixed relative to that slip, and because the connections formed at 53 between the links 49 connect the links for pivotal movement about axes which in all conditions extend parallel to axes 55.

The ring 17 which carries slip-supporting ring 16 is disposed about the latter, and if desired may be formed of several rigidly interconnected parts, as shown. More specifically, this ring 17 may include an upper annular element 56 and a lower annular element 57 retained in vertically spaced relation by an outer short cylindrical ring 58 suitably welded to both of the elements 56 and 57. The inner ring 16 may be removably supported from outer ring 17 by means of a pair of diametrically opposed flat slide elements 59, which are confined between plates 56 and 57 for sliding movement radially toward and away from axis 22. These elements 59 have inner arcuately curved edge portions 60 which are receivable within an outer annular radially outwardly facing groove 61 formed in the outer surface of ring 16, so that the engagement of elements 59 with ring 16 along arcuate areas 62 at the upper side of the edge portions 60 of elements 59 acts to very effectively support ring 16 and the carried slips from ring 17. As will be apparent, the curvature of the inner arcuate edge portions 60 of elements 59 is the same as the curvature of the annular groove 61 formed in element 16. The elements 59 are actuatable radially toward and away from axis 22 and into and out of groove 61 by means of a pair of pins 63 which are rigidly attached to elements 59 and project downwardly therefrom through a pair of slots 64 formed in the lower plate 57 of element 17. Slots 64 are of a length to allow just sufficient sliding movement of elements 59 to move these elements between their active positions of reception within groove 61, and radially outwardly displaced retracted positions in which elements 59 are not received within groove 61, to thus allow upward removal of elements 16 and the carried slips from the rest of the apparatus. The parts 59 may be releasably held in their inner positions by means of a pair of ball detents 65 (see Fig. 2), which are receivable within conical recesses 66 formed in the under surfaces of parts 59. The ball detents 65 are yieldingly urged upwardly by coil springs 67, which may be confined within housings 68 threadedly connected at their upper ends 69 into lower plate 57 of ring 17. As will be apparent, the ball detents 65 are urged upwardly with sufficient force to effectively hold parts 59 in their inner active positions, and yet the force of springs 67 is sufficiently light to be overcome by manual retracting force exerted against actuating pins 63.

The upper rings 16 and 17 and the carried slips 15 are adapted to be power-actuated vertically between the lower full line position of Fig. 3, and the upper broken line

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position of that figure. In the upper position of Fig. 3, the slips 15 are raised sufficiently high to be free of engagement with wedge surfaces 40 of slip bowl segments 14, so that the slips 15 are able to hang freely directly downwardly from ring 16, and thus are displaced farther away from the axis 22 than in the Fig. 1 position. Thus, when the slips 15 are in this way retracted radially outwardly, the opening through the entire apparatus is sufficiently enlarged to pass an enlarged tool joint or other increased diameter element vertically through the apparatus. As the rings 16 and 17 and slips are subsequently lowered toward their Fig. 1 position, the wedge surfaces 40 and 42 co-act to progressively cam slips 15 toward axis 22 and into tight gripping engagement with a pipe 54 received within the apparatus.

The vertical actuation of ring 17 relative to the lower mounting ring 18 is effected by means of the two previously mentioned fluid pressure operated piston and cylinder mechanisms 19. During such vertical actuation, the upper ring 17 is held against any tilting movement or lateral displacement; that is, is held in a proper orientation with respect to axis 22 and ring 18, by means of two sets of levers at opposite sides of the central opening, each set of levers including a first lever 70 and a second lever 71. The functioning of these levers will be discussed in greater detail at a later point. Each piston and cylinder mechanism 19 includes a cylinder 72, one of whose ends has a lug portion 73 which is pivotally attached at 74 to a bearing lug 75 rigidly secured to the upper surface of ring 18. The piston of each mechanism 19 has its piston rod 76 projecting from the opposite end of cylinder 72 and pivotally connected at 77 to a bearing lug 78 which is rigidly attached to the underside of ring 17. The pivotal connection at 74 (see Fig. 1) allows upward swinging movement of the left end of cylinder 72 about a horizontal axis, while the pivotal connection at 77 permits relative pivotal movement of rod 76 and lug 78 about a second horizontal axis extending parallel to the axis at 74. Each of the cylinders 72 extends at an inclination to the horizontal in the lowermost position of Fig. 1, so that when pressure fluid (for example, compressed air) is fed to the lower end of cylinder 72 through inlet 79, the piston and its rod 76 exert force against lug 78 having an upward component, thus resulting in upward displacement of ring 17 relative to ring 18. As seen clearly in Figs. 2 and 3, the two piston and cylinder mechanisms 19 are located at opposite sides of the central pipe passing opening, the lugs 75 and 78 being rigidly attached to rings 18 and 17 respectively toward their outer edges by means of suitable screws represented at 80 (Fig. 2).

The structure 20 for feeding pressure fluid to cylinder 72 includes two complementary rigid metal rings 81 and 82 (see Figs. 1 and 4), which are suitably secured together in any suitable manner as by screws 83, and which are rigidly attached to the underside of ring 18, as by welding of the upper element 81 to ring 18. The two opposed faces of rings 81 and 82 are recessed, to receive therebetween a third rigid preferably metal ring 84, with seal rings 85, 86, 87, 88, 89 and 90 being received between ring 84 and the other two rings. As will be apparent, all of the various rings 81 through 90 are annular and are centered about the vertical axis 22 of the apparatus, and have the cross sectional configurations represented in Fig. 4. Compressed air or other pressure fluid may be fed to a pair of radial passages 91 and 92 in ring 84 through a pair of radially extending pipes 93 and 94 threadedly connected into the outer ends of passages 91 and 92. These pipes 93 and 94 are received within and pass outwardly through a pair of notches 95 cut in the upper edge of stationary element 27, which notches are of a width corresponding substantially to the diameter of pipes 93 and 94 to retain these pipes and the connected ring 84 against rotation with rings 81 and 82. The notches 95 are open at their upper sides to allow pipes

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93 and 94 to move upwardly out of the notches whenever the slip mechanism is removed from the rotary table. Pipes 93 and 94 are of course rigid, but may be connected at their outer ends to flexible hoses 93a and 94a, to allow for the discussed upward removal of the apparatus from the table.

Passage 91 in ring 84 connects through a passage 96 with a space 97 at the underside of ring 84, which space in turn communicates with the previously mentioned line 79 connecting into the lower end of the two cylinders 72. Similarly, the second passage 92 communicates through a passage 98 with an upper space 99, which is connected to a line 100 leading to the upper ends of the two cylinders 72. The seal rings 85 through 90 may be formed of a resiliently deformable seal material, such as rubber or felt, and have the illustrated configurations to effectively confine the air or other pressure fluid against leakage from the two annular spaces 97 and 99, so that fluid is effectively fed from the stationary lines 93 and 94 to the rotating lines 79 and 100 through the ring type swivel connection of Fig. 4. Referring now to Fig. 6, if the pressure fluid utilized for actuating mechanisms 19 is compressed air, that air may be fed to the apparatus from a suitable supply tank 101, which is continuously maintained under the desired pressure by a pump or compressor 102. From tank 101, the compressed air may flow to a multiple position valve 103, which functions as a reversing valve for selectively admitting pressure fluid to either line 93 or line 94, with the second of the lines being a return line through which pressure fluid flows back to valve 103 for discharge through an outlet represented at 104. Thus, valve 103 may be set in a condition for admitting compressed air or other pressure fluid to line 93, to pass through the swivel assembly of Fig. 4 into line 79 leading to the lower ends of cylinders 72, to thus cause the cylinders to elevate rings 16 and 17 and the carried slips 15. In this condition, the pressure fluid from the upper ends of the cylinders returns through lines 100 and 94 to the valve, for discharge at 104. In the reversed condition of valve 103, pressure fluid is admitted to the upper ends of cylinders 72 through lines 94 and 100, and is discharged from the lower ends of the cylinders through lines 79 and 93, to leave the valve at 104. Also, valve 103 of course has a neutral position, in which pressure fluid is admitted to neither end of the cylinders, and the apparatus thus remains at the position to which it has previously been actuated. If the pressure fluid being utilized is not compressed air, but rather is a hydraulic fluid, the fluid discharged from the valve through outlet 104 may be conducted through a suitable line back to the inlet side of pump 102, for recharging into pressure tank 101.

The two levers 70 are pivotally connected at first ends 105 to ring 17, while the levers 71 are pivotally connected at their corresponding ends 106 to the upperside of ring 18. To effect the pivotal attachment of levers 70 to ring 17, these levers are rigidly attached to opposite ends of a horizontally extending connecting shaft 107 (see Fig. 2). More specifically, each end of this shaft may carry a nut 108, which tightens a washer 109 against the end of a corresponding lever 70, the latter containing an opening 110 through which a reduced portion 111 of shaft 107 passes. When nut 108 is tightened, it holds lever 70 against a shoulder 113 formed on shaft 107, to thus secure the two levers 70 in fixed relation to shaft 107. The shaft passes through a pair of bearing lugs 112 attached to the underside of ring 17 in fixed relation thereto, to thus mount shaft 107 and the attached levers 70 to ring 17 for relative pivotal movement about the horizontal axis of shaft 107. The bearing lugs may contain suitable bearing metal sleeves 114, for journaling shaft 107 and for laterally engaging levers 70 to hold shaft 107 and the levers against movement axially of the shaft. The two levers 70 are of course attached

to shaft 107 in a relation such that these levers will always project in the same direction from shaft 107, radially of the axis of that shaft.

The left ends of the two levers 71 (as seen in Fig. 1) are rigidly connected to a horizontal shaft 115, in the same way that levers 70 are connected to shaft 107, and the unit formed by levers 71 and shaft 115 is pivotally attached to the upperside of ring 18 for swinging movement about the horizontal axis of shaft 115 by means of a pair of spaced lugs 116 functioning the same as lugs 112 of the upper shaft. The axes of shafts 107 and 115 are directly parallel to each other and lie in a common vertical plane.

At their right ends (Figs. 1 and 2) levers 70 and 71 each carry a transverse stub shaft 117, secured to the respective levers by nuts 118, and rotatably carrying individual rollers 119, which are rotatable about axes extending parallel to the axes of shafts 107 and 115. The rollers 119 which are carried by shafts 70 are movably received within a pair of guide channels 120 rigidly attached to the upperside of ring 118, while the rollers 119 carried by levers 71 are correspondingly movably received within a pair of guide channels 121 rigidly attached to the underside of rings 17. Each of these guide channels guides the associated roller 119 for movement only horizontally relative to the associated ring 17 or 18, and in a direction directly radially of the shaft 107 or 115 which is attached to the opposite side of the same ring. For confining the roller, each channel forms a horizontal passageway dimensioned to exactly receive the roller, and having shoulders 122 (Fig. 3) extending along its open side for confining the roller against displacement laterally out of the passageway. Intermediate their ends, the levers 70 and 71 curve arcuately away from axis 22 (at 123), to avoid interference with the inner slip mechanism. At their exact midpoints, the levers 70 and 71 of each set of levers are pivotally interconnected for relative pivotal movement about an axis 124, which axis is exactly midway between the axis of shaft 107 and the axis of the roller 119 carried by lever 70, and is also exactly midway between the axis of shaft 115 and the axis of the roller 119 carried by lever 71. Also, axis 124 is of course parallel to the axes of shafts 107 and 115 and rollers 119. The attachment together of levers 70 and 71 at axis 124 may be effected by means of a pair of headed pivot pins 144, which are threadedly connected into levers 70 and pass through bushing sleeves 145 contained within openings 146 in levers 71.

As will be understood, the connection formed between the two rings 17 and 18 by levers 70 and 71 allows vertical movement of ring 17 relative to ring 18, but very positively holds ring 17 in a proper horizontal position and in proper vertical alignment with ring 18 in all positions of the upper ring 17. The upward movement of ring 17 may be limited by engagement of rollers 119 with four stop screws 125 which are adjustably mounted to endwalls 126 of channels 120 and 121.

To assist in supporting the weight of drill pipe 54 when engaged by slips 15, I prefer to provide a pair of spring units 127, positioned at opposite sides of axis 22, and each including a vertically extending coil spring 128 (see Fig. 3) of very substantial strength. This coil spring is contained within a pair of vertically telescopically movable tubular sections 129 and 130, the former of which bears upwardly against upper ring 117, and the latter of which is rigidly attached by screws 131 to lower ring 18. In the lower position of Fig. 3, the downward movement of ring 17 is limited by engagement of that ring with the upper end of tubular member 130. In all positions of ring 17, the two springs 128 remain under considerable compression, to always exert a very substantial upward force against ring 17 tending to support the weight of pipe 54.

In describing the operation of the illustrated apparatus,

assume first that the apparatus is assembled to the Fig. 1 condition, but with the upper ring 17 in its broken line elevated position of Fig. 3. If it is then desired to actuate the slips 15 to positions in which they will effectively support the well spring 54 from the rotary table, the operator actuates the valve 103 of Fig. 6 to a position in which it admits compressed air or other pressure fluid through line 94, swivel unit 20, and line 100 to the upper ends of cylinders 72, to thus cause the pistons to move downwardly within the cylinder 72, and thus lower the ring 17 and the suspended slips 15 to the full line position of Fig. 3 (the Fig. 1 position). As the slips move downwardly, they are cammed radially inwardly by surface 40, to move into tight holding engagement with the well pipe 54. Thus, the well pipe is effectively supported by the slips in fixed relation to the rotatable section 12 of the rotary table. When it is desired to release the pipe 54, the valve 103 may be actuated to a position in which pressure fluid is admitted to the lower ends 79 of cylinders 72, and is discharged from the upper ends of the cylinders, to cause piston rods 76 to exert upward forces against ring 17, to thereby retract the ring upwardly to its broken line position of Fig. 3. In this position, the slips are able to swing outwardly away from the well pipe 54, and thereby free the pipe for vertical movement within the well. In the lower full line position of Fig. 3, ring 17 may be horizontally aligned with the floor structure 132 of the drilling rig.

During the radial movement of the slips 15 into and out of engagement with the pipe 54, the links 46 and 49 act to hold the various slips in a proper interrelationship assuring that all of the slips will engage and hold the pipe. Specifically, the links 46 keep the slips 15 always in positions in which their inner surfaces 44 face inwardly toward axis 22, and the links 49 secure the adjacent slips together for movement in union, and also maintain the inner surfaces 44 of the slips always in essentially vertically extending positions (as in Fig. 1).

If it is desired, the entire slip unit can be removed from the interior of the apparatus, by merely retracting ends 63 and their attached parts 59 radially outwardly, to move parts 59 out of groove 61, so that ring 16 and the suspended slips 15 can be withdrawn upwardly from the rest of the apparatus. When the slips are in use, they are at all times very effectively held in properly centered position relative to axis 22 by virtue of the direct connection of the main supporting body 18 to master bushing 13; that is, the slip structure is all attached directly to the rotating portion of the rotary table, rather than to the outer stationary portion 11 of that table as has generally been the case in prior power slip arrangements. When it is desired to remove the entire power slip apparatus, this may be done by lifting the ring 18 and all of the carried parts upwardly away from the rotary table, withdrawing pins 140 from the sleeves 141 within which they are contained, to leave the bushing 13 accessible for reception of a kelly-drive bushing or other unit. When a kelly-drive bushing is employed, it may have pins corresponding to those shown at 140 and received within the sleeves 141 to rotatably drive the kelly with the bushing.

Fig. 7 represents fragmentarily a slightly variational form of the invention which is adapted for handling a somewhat smaller pipe than in Figs. 1-6. The numerals designating the different parts in Fig. 7 correspond to the numerals of Figs. 1-6, except that primes have been added. In order to convert the Fig. 7 device for handling a smaller pipe, the two semi-circular slip bowl segments 14' are made thicker than the segments 14 of the first form of the invention, with the result that the slips 15' are cammed inwardly farther than in Figs. 1-6, as permitted by links 46', to thus engage and support the smaller size pipe.

I claim:

1. A power slip assembly for use with a well drilling

rotary table having a stationary portion and a rotating portion turning about a vertical axis, said assembly comprising a support structure, means for mounting said support structure to said rotating portion of the rotary table and for rotation therewith about said axis, slips movable vertically relative to said support between lower active positions and upper inactive positions, a carrier structure movably mounted to said support structure and carrying and movable vertically with said slips, means for actuating said carrier structure and slips vertically relative to said support structure, and a plurality of levers pivotally connected near their ends to said support structure and to said carrier structure respectively and pivotally connected to one another at locations intermediate their ends and positively maintaining the carrier structure against tilting movement from a predetermined aligned position with respect to the horizontal as the carrier structure moves vertically to different positions.

2. A power slip assembly for use with a well drilling rotary table having a stationary portion and a rotating portion turning about a vertical axis, said assembly comprising a support structure, means for mounting said support structure to said rotating portion of the rotary table and for rotation therewith about said axis, slips movable vertically relative to said support between lower active positions and upper inactive positions, a carrier structure movably mounted to said support structure and carrying and movable vertically with said slips, means for actuating said carrier structure and slips vertically relative to said support structure, and aligning means for positively maintaining said carrier structure in a predetermined position of alignment with the horizontal as the carrier structure moves vertically to different positions, said aligning means comprising first and second levers having first ends pivotally connected to said support structure and said carrier structure respectively and having second ends connected to said carrier structure and support structure respectively for relative pivotal and horizontal movement but restrained against relative vertical movement, and means pivotally connecting said levers together intermediate said ends thereof.

3. A power slip assembly as recited in claim 2, including two of said pairs of levers between said support structure and said carrier structure at opposite sides of said axis, said actuating means including two inclined pistons and cylinder mechanisms at opposite sides of said axis and connected at opposite ends to said support and carrier structure respectively to actuate the latter vertically relative to said support structure.

4. A power slip assembly as recited in claim 3, including a first rotating fluid feed ring turning with said support structure and a nonrotating feed ring for supplying fluid to said first ring.

5. A power slip assembly for use with a well drilling rotary table having a stationary portion and a rotating portion turning about a vertical axis, said assembly comprising a support structure, means for mounting said support structure to said rotating portion of the rotary table and for rotation therewith about said axis, slips movable vertically relative to said support between lower active positions and upper inactive positions, a carrier structure movably mounted to said support structure and carrying and movable vertically with said slips, a piston and cylinder mechanism turning with said support structure and said carrier structure and operable to actuate the carrier structure and slips vertically relative to said support structure, said piston and cylinder mechanism having an upper end pivotally connected to said carrier structure and a lower end pivotally connected to said support structure and being positioned to swing upwardly from a retracted inclined position to a more vertically extending position as the carrier structure is elevated relative to the support structure, and positioning means guiding said carrier structure for only verti-

cal movement relative to the support structure and restraining the carrier structure against relative tilting or horizontal shifting movement upon actuation of said inclined piston and cylinder mechanism and in spite of the inclination thereof.

6. A power slip assembly for use with a well drilling rotary table comprising a support structure, a carrier structure mounted to said support structure for relative vertical movement, a plurality of circularly spaced slips movably suspended from said carrier structure, a plurality of links suspending said slips respectively and each pivoted at an upper end to said carrier structure and at a lower end to one of the slips to allow radially inward and outward movement of the slips, and a plurality of pairs of additional links movably connecting adjacent slips together, each of said pairs of additional links including a first link pivotally connected, toward a first end thereof, to a first slip for relative pivotal movement about a first generally vertical axis, a second link pivotally connected, toward a first of its ends, to a second and adjacent slip for relative pivotal movement about a second generally vertical axis, and means pivotally connecting said first and second links together toward second ends thereof for pivotal movement relative to one another about a third generally vertical axis.

7. A power slip assembly for use with a well drilling rotary table having a stationary portion and a rotating portion turning about a vertical axis, said assembly comprising a support structure, means for mounting said support structure to said rotating portion of the rotary table and for rotation therewith about said axis, slips movable vertically relative to said support between lower active positions and upper inactive positions, a carrier structure mounted to said support structure for rotation therewith and for vertical movement relative thereto, an essentially annular member centered essentially about said axis, connector means detachably connecting said essentially annular member to said carrier structure for vertical movement therewith, means movably suspending said slips from said member, and means for actuating said carrier structure, and thereby said member and slips, vertically relative to the support structure, said essentially annular member and slips being completely detachable from the carrier structure, said carrier structure being essentially a ring disposed essentially about said member, said connector means comprising a pair of lock elements movably mounted to said ring and each receivable within an outwardly facing recess in said member to detachably support the latter.

8. A power slip assembly as recited to claim 2, in which said first mentioned means comprise means adapted to mount said support structure to a master bushing contained in said rotating portion of the rotary table and for rotation therewith.

9. A power slip assembly as recited in claim 2, in which said first mentioned means include pins projecting downwardly from said support structure and receivable within driving recesses in a master bushing contained in said rotating portion of the rotary table.

10. A power slip assembly as recited to claim 2, in which said first mentioned means include externally non-circular means projecting downwardly from said support structure and receivable within a noncircular recess in a master bushing contained in said rotating portion of the rotary table in a relation to drive the support structure with said bushing.

11. A power slip assembly as recited in claim 2, in which said first mentioned means include a master bushing adapted to be mounted in said rotating portion of the table, and means for attaching said support structure to said bushing for rotation therewith.

12. A power slip assembly as recited in claim 2, in which said actuating means comprise a fluid pressure operated piston and cylinder mechanism for raising and lowering said carrier structure.

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13. A power slip assembly as recited in claim 2, in which said actuating means comprise a fluid pressure operated piston and cylinder mechanism turning with said support structure for raising and lowering said carrier structure, a first fluid inlet ring turning with said support structure, and a second nonrotating fluid inlet ring for feeding fluid to said first ring and sealed with respect thereto, both of said rings being centered about said axis and spaced outwardly therefrom.

14. A power slip assembly for use with a well drilling rotary table having a stationary portion and a rotating portion turning about a vertical axis, said assembly comprising a support structure, means for mounting said support structure to said rotating portion of the rotary table and for rotation therewith about said axis, slips movable vertically relative to said support between lower active positions and upper inactive positions, a carrier structure movably mounted to said support structure and carrying and movable vertically with said slips, a piston and cylinder mechanism turning with said support structure and said carrier structure and operable to actuate the carrier structure and slips vertically relative to said support structure, said piston and cylinder mechanism having an upper end pivotally connected to said carrier structure and a lower end pivotally connected to said support structure and being positioned to

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swing upwardly from a retracted inclined position to a more vertically extending position as the carrier structure is elevated relative to the support structure, and positioning means guiding said carrier structure for only vertical movement relative to the support structure and restraining the carrier structure against relative tilting or horizontal shifting movement upon actuation of said inclined piston and cylinder mechanism and in spite of the inclination thereof, said positioning means including a plurality of levers pivotally connected near their ends to said support structure and said carrier structure respectively and pivotally connected to one another at locations intermediate their ends and maintaining the carrier structure in predetermined orientation with respect to said support structure during said relative vertical movement.

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