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J. A. MOOSMAN
WELL APPARATUS

3,015,362

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2 Sheets-Sheet 1

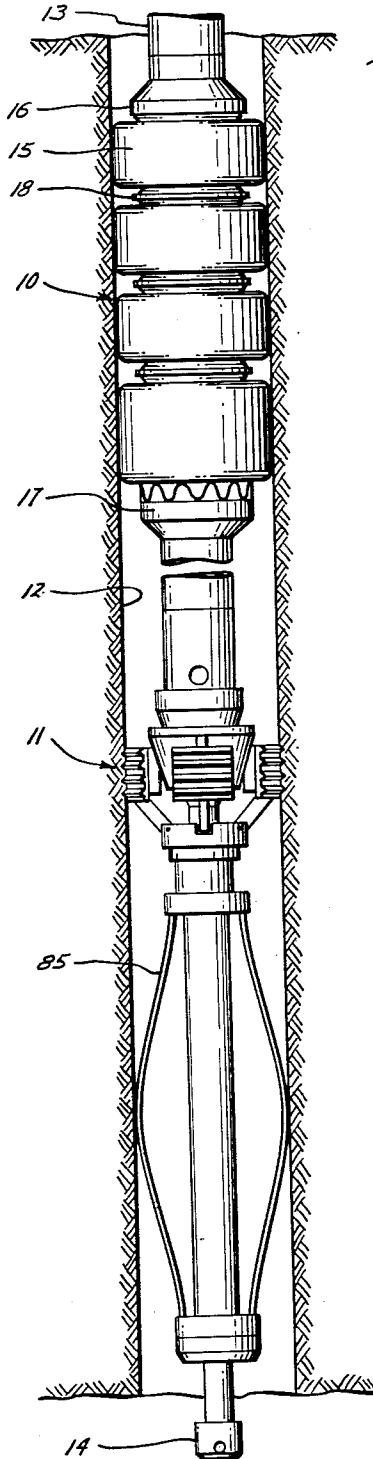


Fig. 1

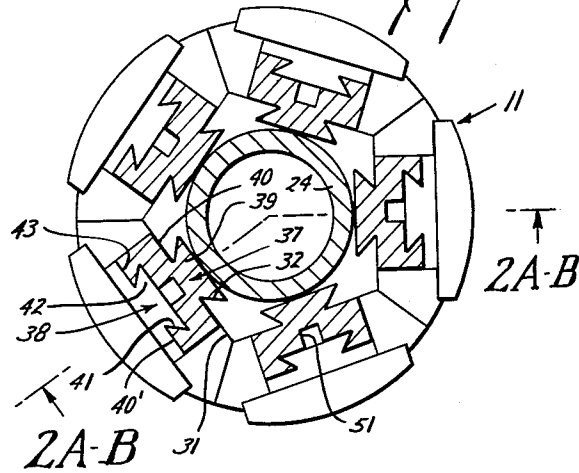


Fig. 3

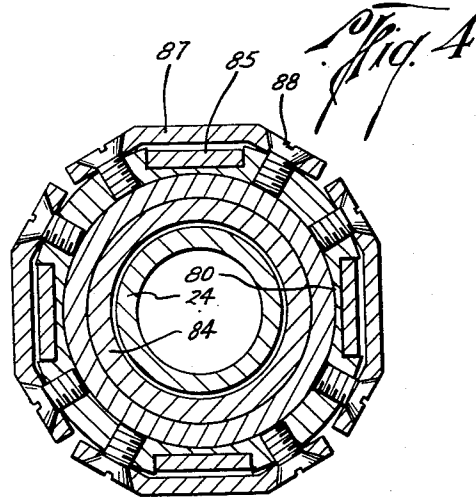


Fig. 4

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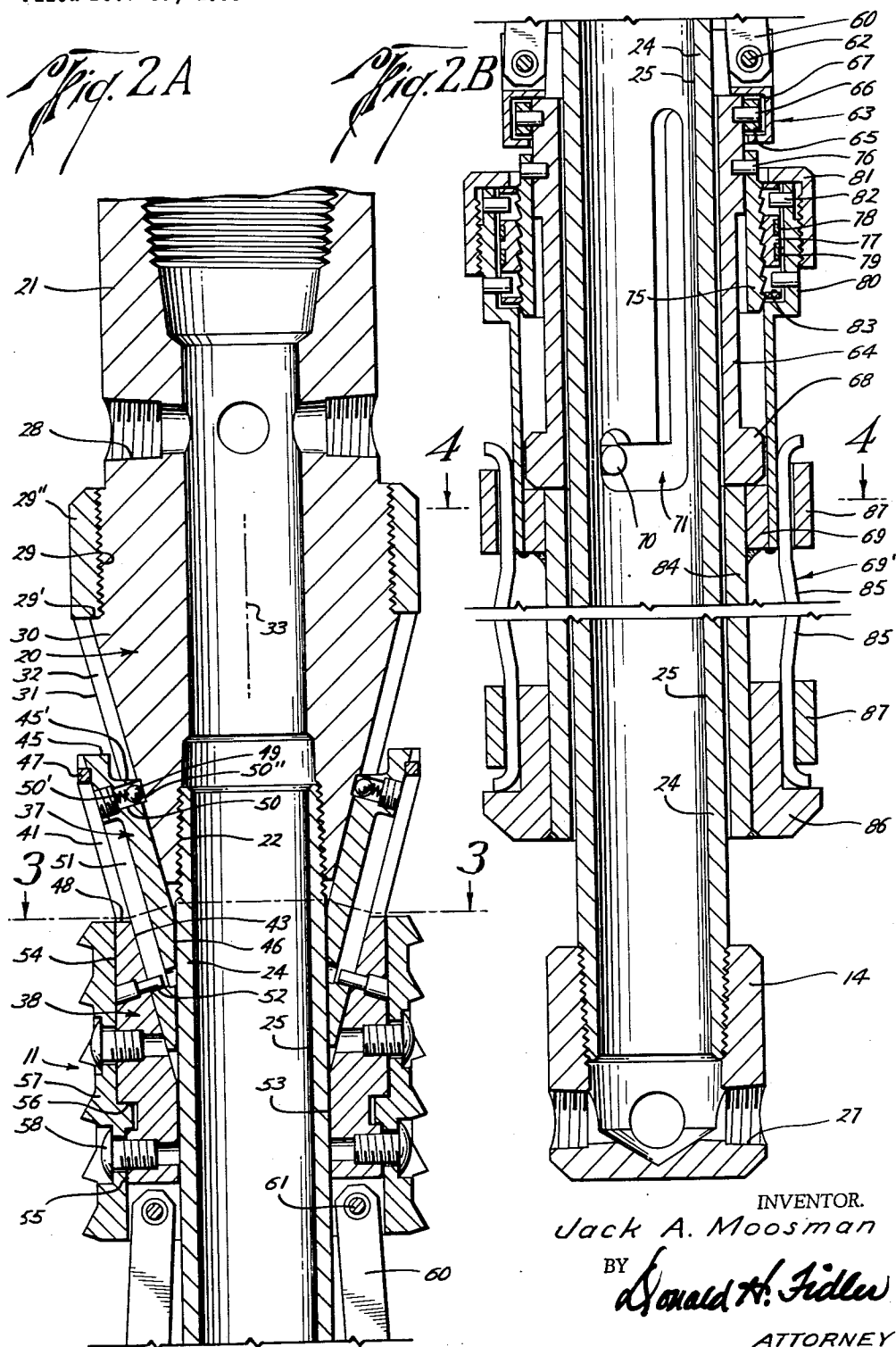
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2 Sheets-Sheet 2



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WELL APPARATUS

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5 Claims. (Cl. 166-216)

This invention relates to well apparatus of the type having expansible gripping means, such as slips, for anchoring a well conduit in a borehole or for setting a packer or the like. More particularly, the invention relates to slip means which are suitable for use in borehole operations wherein it is desired to set the slip means at a level a number of feet off bottom without requiring a long anchor or tail pipe to the bottom.

Where a casing has been set in a borehole the casing presents a fairly uniform hole size so that slip anchoring means, as conventionally employed, have only a short distance to travel axially until they engage the wall surface. Tests have shown that if the hole diameter divided by the packer diameter exceeds 1.2 the chances of getting a successful seal are small. It has heretofore been necessary to provide a plurality of separate packer units and separate slip anchoring means for use in boreholes of various diameters so that the above ratio may be maintained.

In a borehole where no casing has been set, the walls are irregular so that ordinary slip means often fail to properly engage the wall. Prior anchoring devices, such as illustrated in the Patent No. Re. 24,098 by E. W. Bagnell, reissued November 29, 1955, have employed dog members which are projected outwardly into the formation. While this device has enjoyed a certain amount of commercial acceptance it is not suitable for use in casing.

It is therefore an object of this invention to provide a new and improved slip anchor mechanism which may be employed in either cased or open boreholes.

It is a further object of this invention to provide a new and improved slip anchor mechanism which may be universally used in boreholes of various diameters which may be cased or open.

A still further object of the present invention is to provide new and improved slip actuating means having an increased length of axial travel.

Another object of the present invention is to provide new and improved slip actuating assembly having a releasable coupling to permit free rotation of a portion of the assembly relative to another portion.

These and other objects of the invention are attained by means of a slip anchor assembly including a mandrel having a slip actuating bowl, compound arranged slip blocks slidably mounted on each other and on the mandrel slip bowl, and friction means to engage the borehole walls. Longitudinal movement of the mandrel relative to the friction means causes the compound slip blocks to be cammed outwardly into engagement with borehole walls. A releasable connection in the assembly permits the mandrel and slip blocks to be rotated relative to the friction means while in the borehole which facilitates removal of the drill string.

The novel features of the present invention are set forth with particularity in the appended claims. The present invention both as to its organization and manner of operation together with further objects and advantages thereof may best be understood by way of illustration and example of certain embodiments when taken in conjunction with the accompanying drawings in which:

FIG. 1 illustrates the slip actuating means of this invention together with a packer arrangement disposed in a borehole in an expanded position;

FIGS. 2A and 2B are views in longitudinal cross sec-

2

tion of upper and lower portions, respectively, of the slip actuating means in accordance with the principles of the present invention shown in a retracted position;

FIG. 3 is a cross-sectional view taken on the line 3-3 of FIG. 2A;

FIG. 4 is a cross-sectional view taken on the line 4-4 of FIG. 2B.

Referring now to FIG. 1, there is shown a packer assembly 10 and the slip assembly 11 of the present invention which are suitably coupled together as by a threaded connection. The entire apparatus is suspended in a borehole 12 at the lower end of tubing string 13. The lower end of the slip assembly may be suitably closed by means of an end cap 14 or may be connected to a perforated anchor or the like.

The packer assembly 10 may be of any suitable type, for example, as shown in the Patent No. 2,797,759 to T. L. Long, issued July 2, 1957. The packer assembly 10 preferably includes a plurality of annular, "doughnut" type packing elements 15 which are spaced between upper and lower packer heads 16, 17 by spacer plates 18, the plates and packing elements being mounted on a central mandrel (not shown). The upper packer head 16 is arranged to be slidable over the mandrel to permit relative movement with respect to the lower head 17 thereby expanding the packer elements 15 axially. It will be appreciated that this type of packer assembly readily permits interchange of various size packer elements and spacers for different size holes. For further details of the packer assembly, reference may be made to the aforesaid Long patent.

Referring now more particularly to FIG. 2A, the slip or body assembly 11 includes a tubular slip bowl 20 having an upper box end 21 for connection to a packer or the like and a lower box end 22 which threadedly receives a tubular mandrel 24. A central bore 25 extends longitudinally through the assembly. The end cap 14 has ports 27 therein and is threadedly secured to the lower end of the mandrel 24 (FIG. 2B).

The slip bowl 20 has ports 28 therein below the upper box end 21 for fluid ingress and egress. Just below the ports 28 is an enlarged externally threaded portion 29 which extends downwardly to an upwardly facing shoulder 29' formed by the upper end surface of a downwardly extending tapered portion 30 of the bowl. An annular abutment ring 29' is threadedly received by the threaded portion 29 and engages the shoulder 29'. The tapered portion 30 of the bowl is of generally pentagonal cross section and thus includes a plurality of surfaces 31 extending inwardly and downwardly relative to a central longitudinal axis 33 from the upper shoulder to the outer cylindrical surface of the mandrel 24. Cut into each of the surfaces is a dovetail keyway 32 that extends along the length thereof. Although five such surfaces 31 are employed in the disclosed embodiment, it will be appreciated that this number may be varied as desired.

Inner slip blocks 37 and outer slip blocks 38 are arranged as compound slides on the tapered surfaces 31 of the bowl. As seen in FIG. 3, each inner block 37 has a dovetail key 39 extending outwardly away from its inner surface 40 which is slidably received in the dovetail keyway 32 in bowl 20. The outer surface 40' of each inner slip block has a dovetail groove 41 therein which receives a dovetail key 42 projecting outwardly from the inner surface 43 of an outer slip block 38. The inner and outer surfaces 40, 40' of each inner slip block 37 as well as a portion of the inner surface 43 of outer slip block 38 are arranged parallel to the tapered surface 31 of the bowl 20 (FIG. 2A).

Each inner slip block 37 also has an upper end surface 45 which is recessed adjacent the inner surface to present a shoulder 45' which limits upward movement of the slip

block 37 when in engagement with the lower end surface of the abutment ring 29'. The lower end surface 46 of each inner slip block is arranged at an obtuse angle relative to the inner surface 40 so that in a collapsed position the lower end surface abuts the outer wall of the mandrel 24 and is substantially parallel to the central axis 33 of the assembly. Disposed transversely across the upper end of the dovetail keyway 41 in the inner slip block 37 is a bar member 47 which limits the movement of the outer slip block 38 by engaging the end surface 48 thereof when the block is extended.

The inner slip block 37 is releasably secured in the position shown in FIG. 2A by latch means including a ball member 49 received in a transverse bore 50 at the upper end of the block. The ball is biased by a spring 50' into a detent recess 50'' in the bottom surface of dovetail keyway 32 so that the inner slip block 37 is secured relative to the slip bowl 20 until sufficient force is applied to slip block 37 so that the force of the spring 50' is overcome and the ball is retracted into bore 50.

An elongated recess 51 extends longitudinally along the bottom surface of the dovetail keyway 41 and receives a pin 52 which projects from the dovetail key 42 of outer block member 38. The pin 52 when coacting with the lower end surface of the recess 51 serves to retract the inner slip block 37 from an expanded position.

Each outer slip block 38 has an angular inner surface comprised of the inner surface portion 43 which is parallel to the tapered portion and another surface portion 53 disposed at an obtuse angle thereto and parallel to the central axis 33. The outer surface of the slip block includes stepped surface portions 54, 55 and an intermediate grooved portion 56 which are adapted to receive slips 57 having outer surfaces serrated in a well-known manner. Slips 57 are suitably secured to each outer slip block 38, for example, by button head screws 58 threadedly received in the blocks. The lower end portion of each outer slip block 38 is bifurcated so as to provide a recess for receiving one end of a slip rein 60 which may be suitably secured to the slip block, for example, by means of a pin 61.

As shown in FIG. 2B, the other ends of each of the slip reins are similarly secured by pins 62 in suitable recesses in the upper end of annular retainer assembly 63. Annular assembly 63 is loosely mounted on the body assembly 11 to permit relative motion therebetween and is coupled or connected to the body assembly 11 by means of a J slot 71 and pin 70 in a manner which will be more fully explained in the discussion to follow. Assembly 63 also includes wall-engaging friction means 69' having spring members 85 which frictionally engage the sidewall of the well bore to provide frictional forces tending to resist movement of the assembly 63 relative to the well bore. Included in the assembly is a tubular sleeve 64, which is loosely received about the mandrel 24, and has, at its upper end, an annular ring 65 secured to the sleeve by pins 66. The ring is received within an internal annular chamber 67 formed in the upper portion of the retainer assembly 63. The upper end surface of the sleeve 64 and the lower surface of the annular ring 65 provide thrust-bearing surfaces for the retainer assembly 63. The lowermost end of the sleeve has an external flange 68 with a lower surface in abutment with an annular ring 69 of a spring cage or wall-engaging friction means 69'. Extending inwardly from the inner surface of sleeve 64 at its lowermost end is a pin 70 which is suitably mounted in the sleeve. The pin 70 extends into a J type slot 71 which is cut into the mandrel 24. As will hereinafter become more apparent the mandrel 24 may be "unjayed" by rotation and thereafter moved longitudinally relative to the sleeve 64.

Intermediate the ends of the sleeve 64 is an annular member 75 provided with external left hand buttress threads and which is suitably fastened to the sleeve 64, for example as by pins 76. A split nut 77 is threadedly

secured to the annular member 75. The split nut is comprised of a plurality of radial segments internally threaded in a left hand manner and resiliently secured together for radial expansion and contraction by snap rings 78. The split nut 77 is contained within an annular chamber 79 formed by an enlarged flange on a cage sleeve 80 and a threadedly connected cage cap 81 which enclose and substantially prevent axial movement of the split nut 77. To secure the split nut against rotation relative to cage sleeve 80, pins 82 in the cage are received within openings 83 of the nut segments.

The lower end of the cage sleeve 80 is welded to the annular ring 69 which is, in turn, welded to a longitudinally extending tubular sleeve member 84 which loosely surrounds the mandrel 24.

Bowed, resilient spring members 85 having a rectangular cross section are received within longitudinal slots in the upper and lower spring cages 69, 86, and are secured thereto by means of spring clamp members 87. The clamps 87 are secured to the sleeve 80 by flat head screws 88 which are threaded into radial holes in the sleeve (FIG. 4).

In an exemplary operation of the device, the slip assembly and packer are assembled as disclosed and lowered to the level where it is desired to set the packer. While "going in," the pin 70 is in the short arm of the J slot 71 maintaining the slips in a retracted position while the friction springs 85 bearing against the borehole walls cause the sleeve 84 to be forced upwardly against the tubular sleeve 64 thereby preventing the pin 70 from leaving the short arm of the J slot.

At the level where the slips are to be anchored, the drill string is raised slightly, rotated to bring the long arm of the J slot 71 into alignment with the pin 70 and then lowered. During lowering of the mandrel 24, the friction springs 85 prevent the sleeve 64 from moving downward. Hence, the retainer assembly 63, reins 60 and slip block 38 are held against longitudinal movement. The slip bowl 20 moves downwardly with the mandrel 24 with the inner slip block 37 resiliently locked to the bowl by the detent balls 49 so that the outer slip block 38 and slips 57 are cammed outwardly by virtue of the dovetail key 42 and keyway 41. When the outer slip block has moved outwardly to the point where the end surface 48 engages the transverse bar 47, the detent balls are disengaged from recesses 50'' and the inner slip block 37 is cammed outwardly by means of key 39 and keyway 32. Movement of the compound slips outwardly is stopped when the slips 57 engage and dig into the side wall of the borehole. Further downward force on the mandrel thereafter expands the packer in a well-known manner.

When it is desired to remove the anchor, the pipe string is raised releasing the packer. Further upward movement causes bowl 20 to move upwardly which cams the slip blocks inwardly by virtue of dovetail key and keyway arrangement. The outer block 38 will retract inwardly until the pin 52 engages the lower end surface of the elongated recess 51 which then causes retraction of the inner slip block 37 back to its original position.

When removing the drill string from the borehole it is desirable to rotate the drill string in the borehole while restraining a section of pipe above the surface so as to uncouple sections of pipe. To permit free rotation of the mandrel relative to the friction means which might tend to resist rotation, the drill string and mandrel 24 are rotated in a right hand direction which rotates the sleeve 64 by virtue of the pin 70 and the J slot 71. Since ring 65 and thread-carrying member 75 are mounted for free rotation, they rotate with sleeve 64 while the split nut 77 is held against rotation by the friction springs 85. Consequently, the threaded member 75 unscrews from the split nut 77. Thereafter, upward movement of the mandrel causes the end cap 14 to abut the lower end member 86 of the spring cage, but the mandrel and sleeve 64

together with the slips are then freely rotatable with respect to the friction spring assembly.

From the foregoing it will be apparent that a new and improved slip anchor mechanism has been provided with an increased length of axial travel which permits use of the anchor in boreholes of a wide range of diameters. Effective operation is achieved in either open or cased borehole. Moreover, when desired the mandrel and slip assembly are freely rotatable with respect to the friction pad assembly.

While a particular embodiment of the present invention has been shown and described, it is apparent that changes and modifications may be made without departing from the scope of this invention in its broader aspects and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A slip type anchor for use in a borehole comprising: a cylindrical body adapted to be connected at one end to a pipe string for movement therewith, said body having integral first surface portions inclined relative to the longitudinal axis of said body and spaced about said body; first slip block members having inner and outer substantially parallel surface portions with said inner surface portions of said first block members being respectively in slidable contact with said first surface portions; interlocking key and keyway means for locking said first surface portions to said inner surface portions of said first block members while permitting relative sliding movement; second slip block members having inner and outer surface portions with said inner surface portions of said second block members being respectively in slidable contact with said outer surface portions of said inner block members; slip means on said outer surface portions of said second slip block members; interlocking key and keyway means for locking said last-mentioned slidably contacting surface portions to one another while permitting relative sliding movement; an annular assembly slidably mounted on said body and including wall-engaging friction means arranged to frictionally engage wall portions in the borehole; coupling means releasably securing said assembly against longitudinal movement relative to said body; and means connecting said assembly to said second slip block members whereby, upon relative movement in only one direction between said body and said assembly, said first and second block members are moved radially outward from said body while moving in a parallel relationship to one another and to said inclined first surface portions until said slip means are in locking relationship with the borehole wall.

2. A slip type anchor for use in open boreholes comprising: a cylindrical body adapted to be connected at one end to a string of pipe for movement therewith, said body having integral first surface portions inclined relative to the longitudinal axis of said body and spaced about said body; inner slip block members engageable with said first surface portions and respectively having opposed surfaces arranged parallel to each other with one of said inner block surfaces being disposed adjacent one of said first surface portions; interlocking key and keyway means locking said last-mentioned adjacent surfaces together while permitting relative sliding movement; outer slip block members engageable with said inner slip block members, each of said outer slip block members having at least one surface one surface disposed adjacent to the other of said inner block surfaces; interlocking key and keyway means locking said last-mentioned adjacent surfaces together while permitting relative sliding movement; slip means on said outer slip block member; an annular assembly slidably mounted on said cylindrical body; means to couple said annular assembly and said cylindrical body to one another including a J slot and pin connection; means connecting said annular assembly to said outer slip block members comprising link mem-

bers whereby upon relative movement in only one direction, said inner and outer slip block members are moved radially outward from said body while moving in a parallel relationship to one another and to said inclined first surface portions until said slip means are in locking relationship with the borehole, said assembly further including wall-engaging friction means arranged to frictionally engage wall portions in the borehole wall.

3. A slip type anchor for use in a borehole comprising: a cylindrical body adapted to be connected at one end to a string of pipe for movement therewith, said body having integral first surface portions inclined relative to the longitudinal axis of said body and spaced about said body; inner slip block members engageable with said first surface portions and respectively having opposed surfaces arranged parallel to each other with one of said inner block surfaces being disposed adjacent one of said first surface portions; interlocking key and keyway means locking said last-mentioned adjacent surfaces together while permitting relative sliding movement; outer slip block members engageable with said inner slip block members, each of said outer slip block members having at least one surface disposed adjacent to the other of said inner block surfaces; interlocking key and keyway means locking said last-mentioned adjacent surfaces together while permitting relative sliding movement; slip means on said outer block members; an annular assembly including a tubular sleeve loosely mounted about said cylindrical body; means to couple said annular assembly and said body to one another including a J slot and pin connection; means connecting said annular assembly to said outer slip block members comprising link members whereby upon relative movement in only direction, said inner and outer slip block members are moved radially outward from said body while moving in a parallel relationship to one another and to said inclined first surface portion until said slip means are in locking relationship with the borehole; said tubular sleeve having an externally threaded portion, wall-engaging friction means to frictionally engage wall portions in a borehole wall, and a left-hand, internally-threaded split nut means received by said threaded portion and secured relative to said friction means whereby said sleeve may be disconnected from said wall-engaging friction means.

4. A slip type anchor for use in a borehole comprising: a cylindrical body adapted to be connected at one end to a pipe string for movement therewith, said body having integral portions inclined relative to the longitudinal axis of said body and spaced about said body, slip means for each of said inclined portions including pairs of superimposed first and second slip blocks wherein the first of said blocks has substantially parallel inner and outer surface portions and is disposed intermediate of a surface portion on the second slip block and said inclined portion so that said clip blocks may slide parallel to one another and to said inclined portion; means in each pair of slip blocks to slidably secure said first slip block to said inclined portions and to said second slip block; an annular assembly slidably mounted on said body and including a tubular sleeve; coupling means releasably securing said assembly against longitudinal movement relative to said body; means to couple said sleeve to said second slip blocks whereby upon relative movement in only one direction, said first and second block members are moved radially outward from said body while moving in a parallel relationship to one another and to said inclined first surface portion until said slip means are in locking relation with the borehole wall; wall-engaging friction means for frictionally engaging the sidewall of a well bore; and means for releasably coupling said wall-engaging friction means to said sleeve.

5. A slip type anchor for use in a borehole comprising: a cylindrical body adapted to be connected at one end to a pipe string for movement therewith, said body having integral portions inclined relative to the longitudi-

7

nal axis of said body and spaced about said body, slip means for each of said inclined portions including pairs of superimposed first and second slip blocks wherein the first of said blocks has substantially parallel inner and outer surface portions and is disposed intermediate of a surface portion on the second slip block and said inclined portion so that said slip blocks may slide parallel to one another and to said inclined portion; means in each pair of slip blocks to slidably secure said first slip block to said inclined portions and to said other slip block; an annular assembly slidably mounted on said body and including a first tubular sleeve having a left-hand, externally-threaded portion, a second tubular sleeve on said body, wall-engaging friction means secured to said second sleeve, and means on said second sleeve for threadedly coupling said second sleeve to said externally-threaded portion on said first sleeve whereby said friction means

8

may be uncoupled from said first sleeve by rotation; coupling means releasably securing said assembly against longitudinal movement relative to said body; and means to couple said first sleeve to said second slip blocks whereby upon relative movement in only one direction, said first and second block members are moved radially outward from said body while moving in a parallel relationship to one another and to said inclined first surface portion until said slip means are in locking relationship with the borehole wall.

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