

IMPROVED SLIP ASSEMBLY

This invention relates to an hydraulically operated double acting slip assembly useful to grip pipe as required while pipe is being run into or pulled from a well.

U.S. Patent 4,576,254 discloses a slip assembly structure comprising double acting slip systems, which after being operated to grip pipe, automatically gripped the pipe tighter on slight upward or downward movement of the pipe caused by a small upward or downward load on the pipe. These small loads may occur each time the slips are operated to grip pipe as pipe is being run into or pulled from a well through the slip assembly. Slight movement of the pipe automatically causes the slip systems to grip pipe tighter and forces resulting from the tighter grip induce frictional forces between slip assembly members, which are greater than forces applied to the slip assembly members by a pressurized hydraulic operating cylinder to move the slip systems to a position not gripping pipe; therefore, the slip systems cannot be moved inadvertently or on purpose to a position not gripping pipe unless the pipe is repositioned slightly upwardly or downwardly to the precise "neutral" position where the automatic grip tightening system is not operating.

That slip assembly structure more specifically comprises housing means through which pipe is moved into and out of a well, with slips in said housing for gripping the pipe. Means including wedges are provided for driving the pipe-gripping means between gripping and non-gripping positions. The automatic increase of the gripping force on gripped pipe is obtained by means comprising secondary wedges between the wedges and the slips and to which the wedges and slips are slidably secured through dovetails.

Field operation of the slip assembly of the above mentioned U.S. patent showed that operators had to vertically reposition pipe small distances many times, when the slip systems were automatically gripping pipe tighter, before the pipe was at the precise level where the pressurized operating cylinder could move the slip systems to a position not gripping pipe. As a result locating the pipe at a desired position is very difficult and time-consuming. Also, manufacturing problems and expense were experienced with the structure used to position and guide the wedges and slip systems.

An assembly according to the present invention for gripping comprises a slip assembly for gripping pipe comprising housing means through which pipe is moved into and out of a well; means in said housing for

gripping pipe; means for operating said gripping means between positions gripping and not gripping pipe; means associated with said pipe gripping means for automatically increasing grip on gripped pipe in response to subsequent upward or downward longitudinal movement of gripped pipe characterised in that said grip-increasing means are arranged to operate only on upward and downward movements in excess of about 18mm (0.7 inches).

The slip assembly may be hydraulically actuated and can include wedges each carrying a double acting slip system which are moved radially inwardly and outwardly to grip or un grip pipe by rotating camming segments pivotally connected in the inner race of a ring bearing, which is supported in ring segments spaced around the bearing. The camming segments are conveniently grooved top and bottom and are slidably connected to the outside of the slip wedges by engaging segment grooves in a "T" slot in the outside of each wedge. The bearing supporting ring segments can be mounted between upper and lower plates, each of which has an opening, for pipe passage. The bottom plate may have an appropriate connection for connecting the slip assembly to a well servicing unit or wellhead.

An hydraulic operating cylinder can be pivotally

connected to the lower plate and the cylinder piston rod pivotally connected to the camming segments and inner bearing race. To move the wedges and slip systems inwardly to grip pipe, pressure is introduced into the cylinder to extend the piston rod and rotate the bearing inner race and camming segments, sliding the thicker portions of the camming segments between the wedges and ring segments, moving the wedges and slip systems inwardly.

Each wedge can carry a double acting slip system with an insert having teeth on its inner surface, which grips the outside of the pipe on inward movement of the wedges, each slip system being spring loaded to a neutral position. Any up or down load on gripped pipe which causes up or down movement of the pipe and slip systems from neutral position can then be arranged to move the slips automatically inwardly along their wedges, resulting in more tightly gripped pipe. The slip systems can comprise secondary wedges slidable mounted on each wedge for downward and inward movement and slips slidably mounted on each secondary wedge for upward and inward movement, the wedges and slips having pawls which extend into grooves in cam plates attached to the secondary wedges, slidably connecting the wedges, secondary wedges and slips together.

A slip assembly according to the invention is able to include an excellent safety feature which prevents operating the slip assembly, either inadvertently or on purpose, to ungrip pipe when the gripping slips are automatically gripping the pipe tighter. The outward force components resulting from inward movement of the slips up or down along their wedges to automatically grip pipe tighter are transmitted through the wedges and press camming segment surfaces against ring segment surfaces. It can be ensured that the frictional forces between the contacting camming segment and ring segment surfaces are greater than the rotating forces imparted to the camming segments by the pressurized hydraulic cylinder and the camming segments cannot be rotated to move the wedges and slip systems outwardly ungripping the pipe.

Before this slip assembly can be operated to ungrip pipe, the pipe must be vertically repositioned to within the slip systems' neutral band where frictional forces preventing return of the slip systems to the outward position not gripping pipe are not developed. To prevent repeated vertical repositioning of pipe, while hunting a narrow neutral band, the slip assembly of this invention has been provided with additional vertical slip system movement from neutral position of

about 0.7 inches (18mm) upward or downward before the slip systems are automatically moved inwardly to grip pipe tighter and cannot be operated to ungrip.

The slip assembly of this invention may also include improved structure which guides the slip system wedges when moved radially inward and outward and positions the wedges between the upper and lower plates equally spaced around the openings for pipe passage in the plates.

An object of this invention is thus to provide a slip assembly which automatically grips gripped pipe tighter on upward or downward movement of gripped pipe of more than about 0.7 inches (18mm).

Among other desirable features, the invention can provide a slip assembly which cannot be operated to ungrip pipe when gripping pipe tighter, which does not require repeated repositioning of tighter gripped pipe to permit operation to ungrip pipe, and which has improved radial guides for the slip systems.

The invention may also provide an improved slip assembly having slip system elements slidably connected

together for inward movement by cam plates.

The invention will be further described by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a top view drawing of a slip assembly according to the invention.

FIG. 2 is a half section drawing in elevation showing the slip assembly operated to grip pipe.

FIG. 3 is a cross sectional drawing along line 3-3 in FIG. 2, showing the slip assembly operated to ungrip pipe.

FIG. 4 is an isometric drawing showing the slidable connection of wedges and camming segments.

FIG. 5 is an isometric drawing of the wedge with pawls utilized in this invention.

FIG. 6 is an isometric drawing showing the secondary wedge of this invention with cam plates attached.

FIG. 7 is an isometric drawing showing the slip with pawls and insert and detail of a typical pin connection to the wedges and slips.

FIG. 8 is a fragmentary section showing a slip system in neutral position gripping pipe.

FIG. 9 is a fragmentary section drawing showing a slip system automatically gripping downwardly loaded pipe tighter.

FIG. 10 is a fragmentary section drawing showing a slip system automatically gripping upwardly loaded pipe tighter.

FIGS. 1 and 2 show a slip assembly 10 having a lower plate 11 and an upper plate 12. The lower plate has a connection 11a for connecting the lower plate and slip assembly to a well head or well servicing unit. Pivotaly mounted in slot 11b in the lower plate is an hydraulic operating cylinder 13. This operator is attached in the bottom plate slot by a pin 14 through hole 11c in the lower plate and cylinder tab 13a. The pin is retained in the hole by drive pins 15. Connected to the cylinder are conduits 16 and 17, used to conduct pressured fluids into and from the cylinder for operation of the slip assembly. The cylinder has a rod 13b having a hole 13c in which is mounted a bearing 18. An operating arm 19 has rod portion 19a which is inserted through a hole in the bearing, pivotally connecting the operating arm and operator. The connection is secured with pinned castle nut 20.

Mounted between the upper and lower plates are three identical ring segments 21, spaced 120 degrees apart and positioned by upper and lower ring segment extensions 21a protruding into mating grooves 11b and 12a in the lower and upper plates, with pairs of top and bottom bolts 22 passing through holes in the upper and lower plates and screwed into threaded holes in each ring segment, fastening each ring segment to the upper and lower plates. Between the upper and lower plates are rods 23 having pin portions fastened in flat bottom holes in the lower plate with bolts 24 securing a cover 25 and the upper plate to these rods.

Each ring segment 21 has a large radial groove 21b and a small wider groove 21c cut inside. Housed in the larger inside segment grooves is an outer bearing race 26 of sealed ring bearing 27, having seals 28 and an inner race 29. The inner race has holes 29a spaced 120 degrees apart and is housed in grooves 30 in the outside surfaces of three camming segments 31. Screws 32 connect each camming segment to the bearing inner race and each segment is provided with a slot 31a and a cross hole 31b. Each camming segment has an outer arcuate surface 31c and a concentric inner arcuate surface 31d in groove 30. Two of the camming segments are pivotally connected to the bearing inner race by pins 33 surrounded by bushing 34 in holes 31b in the camming segments and two holes 29a spaced 120 degrees apart in the bearing race. A longer pin 35 is passed through holes 19b in the operating arm, hole 31b in the

third camming segment and third hole 29a in the inner bearing race, connecting the arm, camming segment and inner race. Pin 35 is secured with another nut 20.

Each camming segment has an upper radial groove 31e and a corresponding lower radial groove 31f spaced from inner arcuate surface 31d.

Cut across the outer surface of each wedge 36 as shown in FIG. 5, is a "T" slot 36i. Each wedge also has inward extensions 36a and 36b, which are slidably engageable in camming segment grooves 31e and 31f, slidably connecting each camming segment to each wedge as shown in FIG. 4. Each wedge is provided with upper and lower downwardly and inwardly inclined surfaces 36c, a pair of holes 36d, a through opening 36e having a lower flat surface 36f, vertical surfaces 36g and a shoulder 36h.

There are pairs of rods 37 anchored in each ring segment 21 with set screws 38. Each wedge is slidably mounted on a pair of rods in holes 36d between the upper and lower plates for radial inward and outward movement.

Swivelably mounted in each side of each wedge is a pin 39. FIG. 7 shows how each pawl is typically connected to the wedges and slips so that pin flat surface 39a may be rotated plus or minus 10 degrees from vertical.

A secondary wedge 40, shown in FIG. 6, is slidably mounted on each wedge for downward movement only. This wedge has outer and inner vertical surfaces 40a, upper and lower

downwardly and inwardly inclined surfaces 40b, upper and lower downwardly and outwardly inclined surfaces 40c, outer and inner shoulders 40d, an opening 40e having a lower flat surface 40f and a hole 40g.

A slip 41 (FIG. 7) having an insert 42 is slidably mounted on each secondary wedge for upward movement only. The insert has teeth 42a on its inner surface for gripping pipe. An insert is positioned and retained in each slip by a screw 43. The slip also has vertical surfaces 41a, upper and lower downwardly and outwardly inclined surfaces 41b, a recess 41c having a lower flat surface 41d and a shoulder 41e. Pins 39, each having flat surface 39a are swivelably mounted on each side of the slips so that the flat surface may be rotated plus or minus 10 degrees from vertical.

Each slip is slidably connected to a secondary wedge and each secondary wedge slidably connected to a wedge by cam plates 44 attached to each secondary wedge with screws 45 as shown in FIG. 6.

Each cam plate has outer and inner rectangular grooves 44a and 44b, with 40 percent of the outer side of the outer groove inclined upwardly and outwardly on an 8 1/2 degree angle and 40 percent of the inner side of the inner groove inclined upwardly and inwardly on an 8 1/2 degree angle. All inclined surfaces on the wedges, secondary wedges and slips of the invention slip assembly are inclined preferably 8 1/2 degrees from vertical. Inclination angles within a range of 5 to 10 degrees would be satisfactory.

Pivotally connected in each wedge opening 36e by a pin 46 is an arm 47, which extends through secondary wedge opening 40e and into slip recess 41c. A spring 48 in secondary wedge hole 40g is compressed between the top of the arm and a washer 49 under the head on bolt 50 because the spring cannot go through a slot 47a in the arm. The compressed spring applies an upward force on the bolt, lifting secondary wedge 40 to engage outer secondary wedge shoulder 40d with wedge shoulder 36h and causing wedge flat surface 40f to contact the lower flat surface 47b on arm 47. The compressed spring also applies a down force to the arm engaging inner secondary wedge shoulder 40d with slip shoulder 41e and causing arm flat surface 47b to contact wedge flat 36f and slip recess flat surface 41d to align surfaces 36f, 40f and 41d and position slips 41 in mid neutral position not gripping pipe tighter, as shown in FIG. 8.

The slip assembly of this invention may be used to grip pipe run through the assembly into a well by connecting the assembly to a wellhead or into a well servicing unit with connector 11a. Conduits 16 and 17 are connected to a remote pressure source such that pressurized fluid may be selectively delivered to cylinder 13 through either conduit. Conduit 17 is pressurized to move wedges 36 and 40 and slips 41 radially outward to ungrip pipe as shown in FIG. 3. Well pipe P, to be gripped intermittently as it is run or pulled from a well passes through pipe passage 51.

To operate the slip assembly to grip pipe, pressurized fluid is delivered to cylinder 13 through conduit 16 causing

extension of rod 13b from the cylinder, moving operating arm 19. As the operating arm is connected to a camming segment 31 and the inner bearing race with pin 35, movement of the arm rotates the inner bearing race and camming segments connected to the race with pins 33. The wedges 36 carrying secondary wedges 40 and slips 41 are slidably mounted between the upper and lower plates on rods 37 which prevent rotation of the wedges. When the inner bearing race and camming segments are rotated clockwise by extension of the cylinder rod, the camming segments 31 slide across the outside of the wedges and the thicker portions of the camming segments move between the wedges 36 and ring segment grooves 21c, pushing the wedges inwardly until teeth on slip insert 42 contact and grip pipe P as shown in FIG. 2. Inward wedge push and pipe grip is maintained by pressurized fluid in conduit 16 applying continued turning force on the inner race and camming segments from the extended cylinder rod through the arm. When fluid in conduit 17 is pressurized, rod 13b retracts into the cylinder rotating the camming segments to slide a thinner section between the wedges and ring segment grooves, the wedges are pulled radially outward to a position not gripping pipe through the "T" slot connections as the camming segments are connected to the bearing inner race by screws 32 (See FIG. 3).

When the slip assembly has been operated to grip pipe, the resulting outward force compresses the thicker sections of the camming segments between the wedges and ring segments so

that the outer surfaces of wedges 36 push the outer surfaces 31 of the camming segments into ring segment grooves 21c.

The double acting grip tightening slip systems carried between each wedge and slip insert are actuated automatically by upward or downward movement of gripped pipe from the neutral gripped pipe position shown in FIG. 8. A small weight on gripped pipe sufficient to cause downward movement of insert 42 and slip 41 will also move the secondary wedge 40 downwardly on the wedge 36 through slip shoulder 41e contacting secondary wedge inner shoulder 40d. After the secondary wedge is moved downwardly on the wedge about 0.70 inches (18mm), the outer upper and lower downwardly and inwardly inclined secondary wedge surfaces 40b engage the upper and lower downwardly and inwardly inclined wedge surfaces 36c. Downward movement of the secondary wedge moves bolt 50 downwardly compressing spring 48 on arm 47 which cannot pivot downwardly as arm surface 47b is stopped by wedge surface 36f. Further downward movement of the slips and secondary wedges together along wedge inclined surfaces 36c results in inward movement of the secondary wedges, slip and their inserts, causing deeper penetration of the slip teeth into the gripped pipe, increasing pipe grip as shown in FIG. 9. Pins 39 on the wedges and slips sliding in grooves 44a in cam plates 44, which are attached to the secondary wedges, connect the wedges, secondary wedges and slips and provide sliding contact of the vertical and inclined surfaces.

Conversely, a small upward force on gripped pipe sufficient to cause upward movement of inserts 42 and slips 41 on

the secondary wedge will lift arm 47 on recess flat 41d to pivot around pin 46 and compress spring 48. The secondary wedge cannot move upwardly on the wedge as outer secondary wedge shoulder 40d is contacting wedge shoulder 36h. After about 0.70 (18mm) inches of upward slip movement on the secondary wedge, upper and lower inclined slip surfaces 41b will contact the inner secondary wedge upper and lower inclined surfaces 40c. Further upward movement of the slips will move the slips inwardly along secondary wedge surfaces 40c, causing teeth 42a to penetrate into gripped pipe and grip the pipe tighter as shown in FIG. 10. When upward or downward loads on gripped pipe are removed or the slip assembly is not gripping pipe, springs 50 push down on the arms or lift the secondary wedges and slips to be realigned on the arm lower surface, returning the slip systems to mid neutral position as shown in FIGS. 2 and 8.

When pipe loads up or down are sufficient to cause automatic operation of the grip tightening slip systems, increased outward forces resulting from increased inward forces on tighter gripped pipe are transmitted through slips, secondary wedges and camming segments, pressing the outer camming segment surfaces 31c into ring segment grooves 21c. Frictional forces generated between these contacting surfaces acting through the radial distance to the center of the pipe are great enough to prevent the pressurized cylinder from rotating the camming segments to move the wedges radially outward to ungrip the

pipe. Therefore, the slip assembly of this invention cannot be operated, either inadvertently or on purpose, to ungrip pipe when the slip systems are automatically gripping pipe tighter.

To operate the slip assembly to ungrip tighter gripped pipe, the pipe must be moved upwardly or downwardly to move the slips back into the neutral band less than 0.70 (18mm) inches above or below the mid neutral position of the slip systems, as shown by FIGS. 2 and 8.

When the slip systems are not gripping pipe tighter or gripping pipe, springs 48 are free to extend pushing the arms and slips downwardly or lifting the secondary wedge until flat surfaces 36f, 40f and 41d are contacting arm lower surface 47b aligning the wedges, secondary wedges and slips in mid neutral position.

CLAIMSGB

1. A slip assembly for gripping pipe comprising:
 - (a) housing means through which pipe is moved into and out of a well;
 - (b) means in said housing for gripping pipe;
 - (c) means for operating said gripping means between positions gripping and not gripping pipe; and
 - (d) means associated with said pipe gripping means for automatically increasing grip on gripped pipe in response to subsequent upward or downward longitudinal movement of gripped pipe in excess of about 0.7 inches (18mm).
2. The slip assembly of claim 1 wherein the means for automatically increasing grip on initially gripped pipe includes means for automatically returning said gripping means to neutral position when said gripping means are not gripping pipe.
3. The slip assembly of claim 1 or claim 2 wherein said means gripping pipe comprises slips operated through connecting pins and cam plates actuating said tighter gripping of gripped pipe after the minimum upward or downward movement.
4. The slip assembly of any one of claims 1 to 3 further including means for preventing the operating means from operating the gripping means to the position not



gripping pipe when said gripping means are automatically increasing grip on gripped pipe.

5. The slip assembly of any one of claims 1 to 4 wherein the means for gripping pipe comprise:

- (a) wedges mounted for radial movement in the slip housing;
- (b) a secondary wedge slidably connected on each wedge; and
- (c) a slip slidably connected on each secondary wedge.

6. The slip assembly of claim 5 wherein the gripping means further includes means for slidably connecting a slip to a secondary wedge and a secondary wedge to a wedge.

7. The slip assembly of claim 6 wherein the means slidably connecting a slip to a secondary wedge and a secondary wedge to a wedge comprise:

- (a) pins swivelably connected into each side of a wedge and a slip, each said pin having a flat surface; and
- (b) cam plates connected on each side of a secondary wedge, said cam plates having inner and outer grooves, said flat surfaces on said wedge pins slidable in said cam plate outer grooves and said slip pins slidable in said cam plate inner



11. The slip assembly of claim 10 wherein the wedge, secondary wedge and slip inclined surfaces are inclined $8\frac{1}{2}^{\circ}$ from vertical.

12. The slip assembly of claim 2 in combination with any one of claims 5 to 11 wherein the means for automatically returning the gripping means to neutral position comprise:

- (a) an arm pivotally connected in each wedge opening, said arm extending through the secondary wedge opening into the slip recess, said arm having a lower flat surface;
- (b) a spring mounted in the secondary wedge opening so that said spring applies a downward force on said arm; and
- (c) lower flat surfaces in said wedge opening, said secondary wedge opening and said slip recess, said flat surfaces engageable with said arm lower flat surface.

13. The slip assembly of any one of claims 1 to 3 wherein the means for operating the gripping means between positions gripping and not gripping pipe comprise:

- (a) ring segments mounted in the housing;
- (b) a radial bearing supported in said ring segments;
- (c) camming segments mounted in said radial bearing, said camming segments pivotally connected to



each other;

- (d) a wedge having a slip segment slidably connected to each camming segment; and
- (e) means in said housing for rotating one of said camming segments.

14. The slip assembly of claim 13 wherein the means for rotating one camming segment is a hydraulic cylinder connected to the housing and a camming segment.

15. The slip assembly of claim 13 or claim 14 wherein the means for preventing the operating means from operating the gripping means to a position not gripping pipe when said gripping means have been operated to grip pipe and are automatically increasing grip on gripped pipe are outward forces resulting from increased grip on gripped pipe which develop frictional forces between the camming segments and ring segments.

16. An hydraulically operated double acting slip assembly comprising:

- (a) housing means including,
 - a lower plate with a connector thereon and a passage for pipe therethrough,
 - an upper plate,
 - a cover secured to said upper plate with a passage for pipe therethrough, and
 - ring segments between said plates around said



- pipe passages,
said segments connected to said plates;
- (b) a pair of guide rods anchored in each said ring segments;
- (c) pipe gripping means, slidably mounted on said rods for gripping pipe passing through said passages including,
double acting slip means for gripping pipe and gripping gripped pipe tighter including pins and cam plates, said slip means automatically actuated to grip pipe tighter by load on gripped pipe causing more than about 0.70 inches (18mm) upward or downward movement of pipe;
- (d) operating means for moving said gripping means inwardly and outwardly along said guide rods to grip and un grip pipe; and
- (e) means preventing said operating means from moving the gripping means outwardly to a position not gripping pipe when said double acting slip means are automatically gripping gripped pipe tighter.

17. The slip assembly of claim 16 wherein the pipe gripping means comprise:

- (a) a wedge slidably mounted on each pair of guide rods, said wedge having a "T" slot across the outer surface thereof, spaced apart upper and lower downwardly and inwardly inclined surfaces



on the inner surface thereof and an opening between said "T" slot and said inner surface, said opening having a lower flat surface;

- (b) a secondary wedge having spaced apart upper and lower downwardly and inwardly inclined surfaces on the outer surface thereof, upper and lower downwardly and outwardly inclined surfaces on the inner surface thereof and an opening between said inner and outer surfaces, said opening having a lower flat surface;
- (c) slip means including a slip having spaced apart upper and lower downwardly and outwardly inclined surfaces and a recess on the outer face thereof, said recess having a lower flat surface;
- (d) means slidably connecting said secondary wedges to said wedges and said slips to said secondary wedges so that said outer secondary wedge surfaces slide on said wedge inner surfaces and said outer slip surfaces slide on said inner secondary wedge surfaces;
- (e) means preventing said secondary wedges from sliding upwardly on said wedges;
- (f) means preventing said slips from sliding downwardly on said secondary wedges; and
- (g) means for positioning each slip and secondary wedge in mid neutral position on each wedge.



18. The slip assembly of claim 17 wherein the means slidably connecting secondary wedges to wedges and slips to secondary wedges comprise:

- (a) pins swivelably connected into each side of the wedges and slips, each said pins having a flat surface;
- (b) cam plates connected each side of said secondary wedge, said cam plates having inner and outer grooves, said flat surfaces on said wedge pins slidable in said cam plate outer grooves and said flat surfaces on said slip pins slidable in said cam plate inner grooves.

19. The slip assembly of claim 18 wherein the cam plate grooves are rectangular in cross-section and the upper portion of the outside of the outer groove is inclined upwardly and outwardly $8\frac{1}{2}^{\circ}$ from vertical and the upper portion of the inside of the inner groove is inclined upwardly and inwardly $8\frac{1}{2}^{\circ}$ from the vertical.

20. The slip assembly of any one of claims 17 to 19 wherein the wedge, secondary wedge and slip inclined surfaces are inclined 5° - 10° from vertical.

21. The slip assembly of claim 20 wherein the wedge, secondary wedge and slip inclined surfaces are inclined $8\frac{1}{2}^{\circ}$ from vertical.



22. The slip assembly of any one of claims 17 to 21 wherein the slip means comprise a slip insert having an inner surface for gripping pipe anchored in each slip.

23. The slip assembly of any one of claims 17 to 22 wherein the means preventing the secondary wedges from sliding upwardly on the wedges comprise:

- (a) a downwardly facing shoulder on the inner surface of each wedge; and
- (b) an upwardly facing shoulder on the outer surface of each secondary wedge.

24. The slip assembly of any one of claims 17 to 23 wherein the means preventing the slips from sliding downwardly on the secondary wedges comprise:

- (a) a downwardly facing shoulder on the outer surface of each slip; and
- (b) an upwardly facing shoulder on the inner surface of each secondary wedge.

25. The slip assembly of any one of claims 17 to 24 wherein the means for positioning each slip and secondary wedge in mid neutral position on each wedge comprises:

- (a) an arm pivotally connected in each wedge opening, said arm extending through the secondary wedge opening into the slip recess and having a lower flat surface;



- (b) a compressed spring mounted around a bolt anchored in a hole in said secondary wedge so that said spring applies a downward force on said arm; and
- (c) lower flat surfaces in said wedge opening, said secondary wedge opening and said slip recess flat surfaces engageable with said arm lower flat surface.

26. The slip assembly of any one of claims 17 to 25 wherein the operating means comprise:

- (a) an hydraulic cylinder having a rod, said cylinder mounted on the lower plate;
- (b) conduits for delivering pressurized fluid to said cylinder for extending and retracting said rod from and into said cylinder;
- (c) a radial bearing supported in the ring segments, said bearing having an inner race and an outer race;
- (d) camming segments supported by and connected to said bearing inner race, said segments pivotally connected to each other and slidably connected to the wedges; and
- (e) an arm pivotally connected to said rod and pivotally connected to said bearing inner race and one of said camming segments.

27. The slip assembly of claim 26 wherein the radial



bearing is a sealed bearing.

28. The slip assembly of claim 26 or claim 27 further including a bearing swivelably mounted in the arm between said arm and the rod.

29. The slip assembly of any one of claims 26 to 28 wherein the means preventing outward movement of the gripping means are outward forces on the camming segments resulting from the slips automatically gripping pipe tighter which develop frictional forces between the outer surface of the camming segments and the contacting wide groove areas in each ring segment.

30. An hydraulically operated double acting slip assembly comprising:

- (a) a lower plate with a connector thereon and a passage for pipe therethrough;
- (b) an hydraulic operating cylinder pivotally connected to said lower plate, said cylinder having a rod extensible therefrom;
- (c) an upper plate;
- (d) a cover secured to said upper plate with a passage for pipe therethrough;
- (e) ring segments, having horizontal grooves therein, disposed around said pipe passages and connected between said plates;
- (f) pairs of guide rods anchored in each said ring



segment;

- (g) a radial bearing having an outer race and an inner race, said outer race supported in said ring segment grooves;
- (h) camming segments having outer grooves wherein said bearing inner race is mounted, said camming segments connected to each other and fastened in said inner race;
- (i) pipe gripping means slidably mounted on each pair of guide rods for inward and outward movement, said pipe gripping means including,
 - a wedge slidably mounted on each pair of guide rods, said wedge having a slot across the outer surface thereof, spaced apart upper and lower downwardly and inwardly inclined surfaces and a downwardly facing shoulder on the inner surface thereof,
 - pins swivelably connected into each side of said wedge, and an opening between said slot and said inner surface, said opening having a lower flat surface and said wedge having
 - an arm pivotally mounted in said opening, said arm having a lower flat surface,
 - a secondary wedge having spaced upper and lower downwardly and inwardly inclined surfaces and an upwardly facing shoulder on



the outer surface thereof, upper and lower downwardly and outwardly inclined surfaces and an upwardly facing shoulder on the inner surface thereof and an opening between said inner and outer surfaces, said opening having a lower flat surface, a slip having spaced apart upper and lower downwardly and outwardly inclined surfaces, an upwardly facing shoulder, pins swivelably connected into each side of said slip and a recess on the outer face thereof, said recess having a lower flat surface, said slip also having an insert anchored therein, said insert having an inner surface for gripping pipe, cam plates connected each side of said secondary wedge, said cam plates having inner and outer grooves, said wedge pins slidable in said outer grooves and said slip pins slidable in said inner grooves, a spring anchored in said second secondary wedge biasing said arm downwardly to engage to lower flat surface thereon with said wedge lower flat surface, said secondary wedge lower flat surface and said slip lower flat surface to align said wedge, said secondary wedge and said slip; and

- (j) an arm pivotally connected to said cylinder rod on one end and pivotally connected to one of



said camming segments and said bearing inner race on the other.

31. A slip system, for use in a slip assembly for gripping pipe passing through the assembly, including a double acting slip automatically moving inwardly to grip gripped pipe tighter by more than about 0.70 inches upward or downward movement of said slip, each slip system comprising:

- (a) a wedge mounted for inward and outward movement in the assembly to grip and ungrasp pipe, said wedge having an outer surface, spaced apart upper and lower downwardly and inwardly inclined surfaces on the inner surface thereof and an opening between said outer and inner surfaces, said opening having a lower flat surface;
- (b) a secondary wedge slidably connected on said wedge, said wedge having spaced apart upper and lower downwardly and inwardly inclined surfaces on the outer surface thereof, upper and lower downwardly and outwardly inclined surfaces on the inner surface thereof and an opening between said inner and outer surfaces, said opening having a lower flat surface;
- (c) slip means including spaced apart upper and lower downwardly and outwardly inclined surfaces and a recess on the outer surface thereof, said



recess having a lower flat surface;

- (d) means including pins and cam plates for slidably connecting said secondary wedges to said wedges and said slips to said secondary wedges so that said outer secondary wedge surfaces slide on said wedge inner surfaces and said outer slip surfaces slide on said inner secondary wedge surfaces;
- (e) means preventing said secondary wedges from sliding upwardly on said wedges;
- (f) means preventing said slips from sliding downwardly on said secondary wedges; and
- (g) means for positioning each slip and secondary wedge in mid neutral position on each wedge.

32. The slip system of claim 31 wherein the wedge, secondary wedge and slip inclined surfaces are inclined 5°-10° from vertical.

33. The slip system of claim 32 wherein the wedge, secondary wedge and slip inclined surfaces are inclined 8½° from vertical.

34. The slip system of any one of claims 31 to 33 wherein the slip means comprise a slip insert having an inner surface for gripping pipe anchored in each slip.

35. The slip system of any one of claims 31 to 34



wherein for slidably connecting secondary wedges to wedges and slips to secondary wedges:

- (a) the pins are swivelably connected into each side of the wedges and slips, each said pin having a flat surface;
- (b) the cam plates are connected each side of each secondary wedge, said cam plates having inner and outer grooves, said flat surfaces on said wedge pins slidable in said cam plates outer grooves and said flat surfaces on said slip pawls slidable in said cam plates inner grooves.

36. The slip system of claim 35 wherein the cam plate grooves are rectangular in cross-section and the upper portion of the outside of the outer groove is inclined upwardly and outwardly $8\frac{1}{2}^{\circ}$ from vertical and the upper portion of the inside of the inner groove is inclined upwardly and inwardly $8\frac{1}{2}^{\circ}$ from the vertical.

37. The slip system of any one of claims 31 to 36 wherein the means preventing the secondary wedges from sliding upwardly on the wedges comprise:

- (a) a downwardly facing shoulder on the inner surface of each wedge; and
- (b) an upwardly facing shoulder on the outer surface of each secondary wedge.

38. The slip assembly of any one of claims 31 to 37



wherein the means preventing the slips from sliding downwardly on the secondary wedges comprise:

- (a) a downwardly facing shoulder on the outer surface of each slip; and
- (b) an upwardly facing shoulder on the inner surface of each secondary wedge.

39. The slip system of any one of claims 31 to 38 wherein the means for positioning each slip and secondary wedge in mid neutral position on each wedge comprises:

- (a) an arm pivotally connected in each wedge opening, said arm extending through the secondary wedge opening into the slip recess and having a lower flat surface;
- (b) a compressed spring mounted around a bolt anchored in a hole in said secondary wedge so that said spring applies a downward force on said arm; and
- (c) lower flat surfaces in said wedge opening, said secondary wedge opening and said slip recess flat surfaces engageable with said arm lower flat surface.

40. A slip assembly for gripping pipe comprising:

- (a) housing means through which pipe is moved into and out of a well;
- (b) means in said housing for gripping pipe including wedges mounted for radial movement in



said housing,
a secondary wedge on each wedge,
a slip on each secondary wedge, and
means slidably connecting said slips to said
secondary wedges and said secondary wedges to
said wedges, said slidably connecting means
including

pins swivelably connected into each side of
the wedges and slips, each said pin having a
flat surface, and
cam plates connected each side of said
secondary wedge, said cam plates having
inner and outer grooves, said flat surfaces
on said wedge pins slidable in said cam
plate outer grooves and said flat surfaces
on said slip pins slidable in said cam plate
inner grooves;

- (c) means for operating said gripping means between
positions initially gripping and not gripping
pipe;
- (d) means associated with said pipe gripping means
for automatically increasing initial gripping
force on gripped pipe in response to subsequent
upward or downward longitudinal movement of
gripped pipe in excess of about 0.7 inches
(18mm); and
- (e) means preventing said operating means from
operating said gripping means to the position
not gripping pipe when said gripping means are



automatically increasing gripping force on initially gripped pipe.

41. The slip assembly of claim 40 wherein the means for automatically increasing gripping force on initially gripped pipe includes means for automatically returning said gripping means to neutral position when said gripping means are not gripping pipe.

42. A slip assembly constructed and arranged for use and operation substantially as described herein with reference to the accompanying drawings.
