

Jan. 31, 1956

L. DAVIS

2,732,901

HYDRAULICALLY OPERATED PULLING TOOL

Filed April 16, 1951

3 Sheets-Sheet 2

Fig. 4

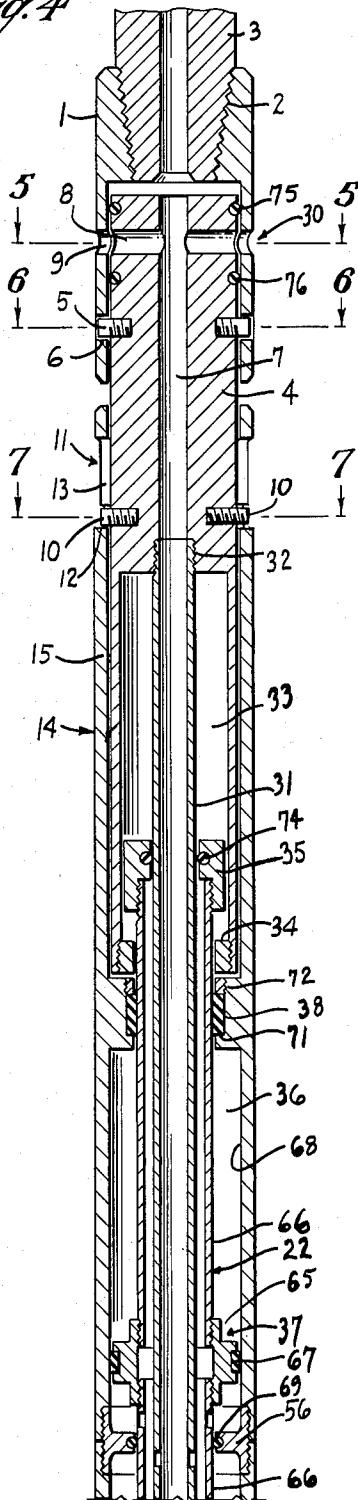
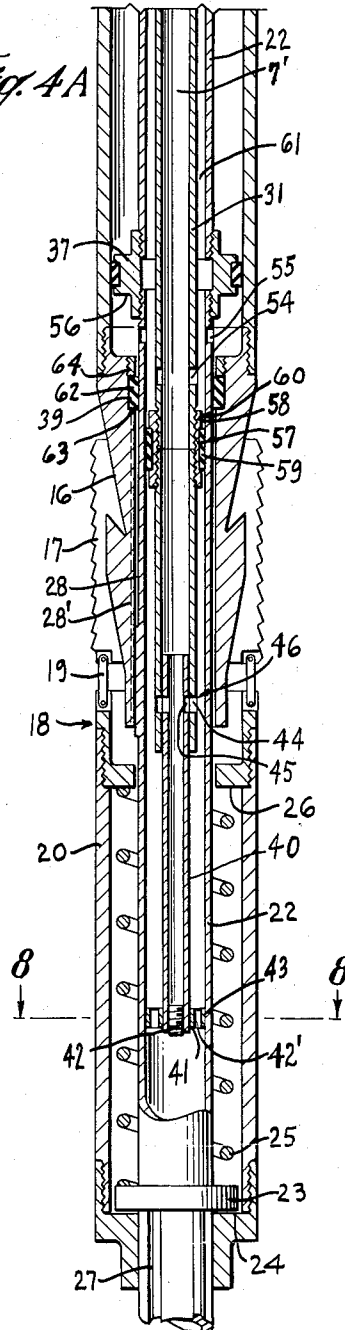


Fig. 4A



Louis Davis
INVENTOR.

BY Lester B. Clark

ATTORNEY

Jan. 31, 1956

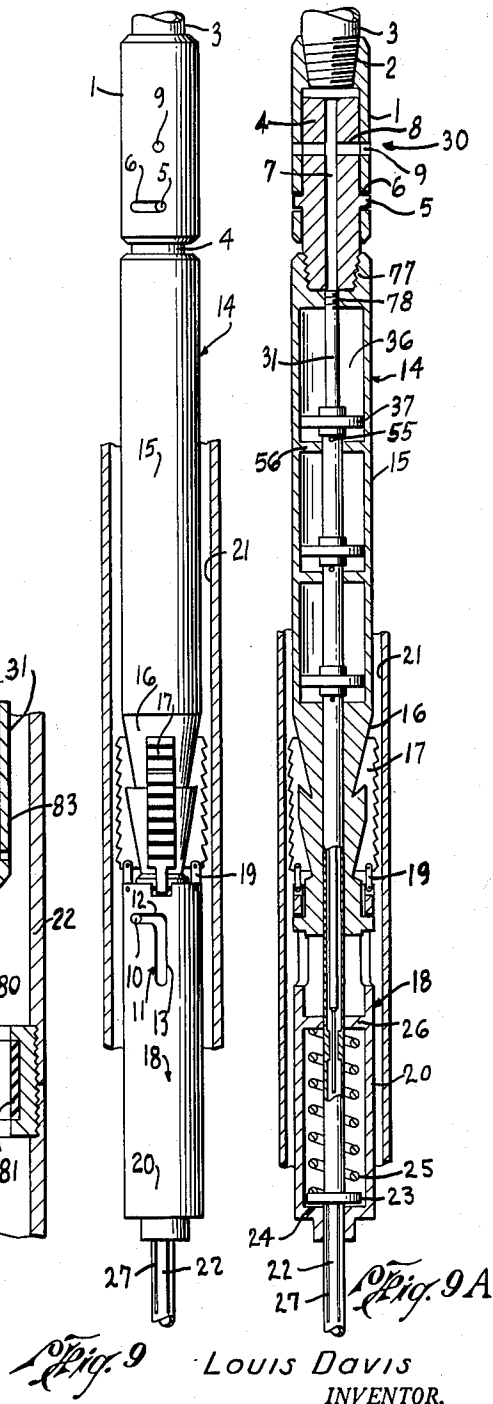
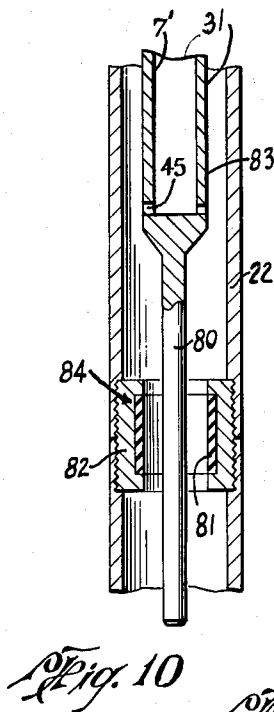
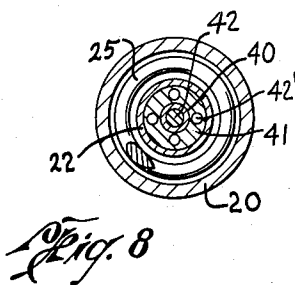
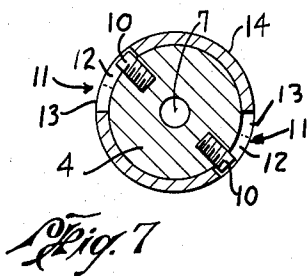
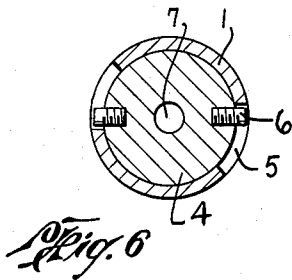
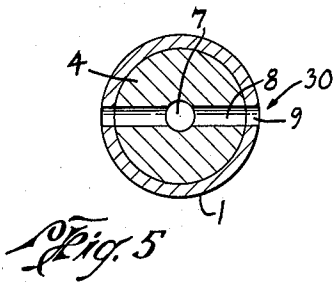
L. DAVIS

2,732,901

HYDRAULICALLY OPERATED PULLING TOOL

Filed April 16, 1951

3 Sheets-Sheet 3



1

2

2,732,901

HYDRAULICALLY OPERATED PULLING TOOL

Louis Davis, Corpus Christi, Tex., assignor of one-third to Ray H. Hostutler, Corpus Christi, and one-third to Floyd Alvernest Williams, Austin, Tex.

Application April 16, 1951, Serial No. 221,190

3 Claims. (Cl. 166—98)

This invention relates to a pulling or lifting tool, such as a tool adapted to be lowered on a tubular string into a well bore to engage, and then lift, an object therein. It is an object of this invention to provide a tool of this class which is adaptable to lift the object upon the application of fluid pressure into the tool.

It is an object of this invention to provide a tool of this class which is equipped with slip members adapted to engage the well bore upon relative rotation between two parts of the tool.

It is a further object of this invention to provide a tool of this class which has a continuous flow passage for well bore fluid therethrough which can be closed upon rotation of the drill string so that fluid pumped down the string into the tool may be employed to lift the engaged object.

It is another object of this invention to provide a tool of this class which can easily be released from an engaged object, or which can be rotated to cut itself away from an engaged object, in case the engaged object cannot be lifted.

It is a further object of this invention to provide a tool of this class which has a plurality of pistons operable in cylinder means therein to lift an engaged object.

It is a further object of this invention to provide a tool of this class which is adapted to place an initial strain or lifting force on an engaged object, and which is adapted to add thereto the lifting force of a plurality of pistons operable by hydraulic pressure.

It is also an object of this invention to provide a tool of this class which is releasable from an engaged object upon relative movement between the drill string and elements of the tool operable therewith.

Other and further objects will be apparent when the specification is considered in connection with the drawings in which:

Fig. 1 is an elevation of one modification of pulling tool;

Fig. 2 is a sectional elevation of the tool shown in Fig. 1;

Fig. 3 is a sectional elevation, similar to the elevation in Fig. 2, which shows the tool of Figs. 1 and 2 in a later stage of operation;

Fig. 4 is a sectional elevation through the upper part of the tool shown in Figs. 1-3;

Fig. 4-A is a sectional elevation through the lower part of the tool shown in Figs. 1-3;

Fig. 5 is a sectional plan view taken along line 5-5 of Fig. 4;

Fig. 6 is a sectional plan view taken along line 6-6 of Fig. 4;

Fig. 7 is a sectional plan view taken along line 7-7 of Fig. 4;

Fig. 8 is a sectional plan view taken along line 8-8 of Fig. 4-A;

Fig. 9 is an elevation showing a second modification of pulling tool;

Fig. 9-A is a sectional elevation through the tool shown in Fig. 9;

Fig. 10 is an enlarged, fragmentary sectional elevation showing in detail the valve of Fig. 9-A.

As shown in Fig. 1, the housing, or connection element 1 is secured by screw threads 2 on the lower end of a tubular string, as the drill string 3, which extends into a well bore from the top of the well. The connector 1 is sleeved on and suspends a central stud or tubular member 4 having oppositely disposed radially extending lugs 5 thereon for lost motion rotary engagement in slots 6 extending circumferentially in the housing 1. This central tubular member has an axially extending fluid passage 7 therethrough and lateral ports 8 extending therefrom for alignment with ports 9 in the housing 1 when the housing and tubular member are in the relative position shown in Figs. 1 and 2.

Spaced below the connector sleeve 1 is a tubular body 15 whose upper end surrounds and has rotary and axial sliding bearing on the lower end of the stem 4. The wall of the body 15 is formed with a J-slot 11 to slidably receive a lug 10 projecting radially from the stem 4. As shown in Fig. 1, the lug 10 is the lower or horizontal leg 12 of the J-slot, and the vertical leg 13 is to the right thereof. The lower end of the body 15 of the mandrel assembly 14 is tapered at 16 to slidably fit corresponding tapers on slip members 17, keyed to the mandrel to rotate therewith. These slip members 17 are part of a slip assembly 18 which includes shackle links 19 pivotally connecting the slip members to a cage or housing 20. It can be seen that in order to expand the slip members 17 it is necessary to maintain the slip assembly 18 substantially stationary so that the mandrel body 15 may move downwardly with relation thereto to force the slip members 17 outwardly to grasp the casing of the well bore 21, as shown in Fig. 3. This is accomplished by providing a tubular ram or piston and rod assembly to fit slidably within the tool assembly, as will be hereinafter described, and within the housing 20, so that the collar 23 thereof will seat on a shoulder 24 formed on the lower end of the housing. A coil spring 25 enclosed by the housing 20 bears, at its lower end, upon the top surface of the collar 23, and at its upper end bears upon the partition or shoulder 26 in the upper part of the housing 20. The ram tube or piston rod 22 is splined at 27 near its lower end for a non-rotatable sliding fit with the bottom wall or shoulder 24 of the slip housing 20, and, as best seen in Figs. 2 and 3, the additional rod splines 28 slide in the grooves 28' in the tapered head 16 of the mandrel.

It can thus be seen that the drill string 3 and connector sleeve 1 may be rotated counterclockwise from the Fig. 1 position to place the left end of the slot 6 against the lug 5, whereby the previously registering ports 8 and 9 of the upper valve 30 are then out of aligned communication. Further counterclockwise rotation of the drill string 3 and housing 1 will thereafter be transmitted through the lug 5 to carry the tubular member 4 with the housing and drill string, so that the lug 10 slides in the horizontal slot 12 from the left in Fig. 1 to the bottom of the vertical leg 13 of the J-slot 11. Thereafter, the lug 10 no longer suspends the heavy mandrel body 15 and the mandrel assembly 14 is free to slide downwardly on the member 4 so that the tapered or wedge portions 16 of the mandrel body can force the slip members 17 outwardly into gripping contact with the well bore 21.

The tubular member 4 has, as a downwardly extending part thereof, the pipe or tubing 31 which is connected thereto at 32 for placing the bore or central passage thereof in communication with the bore 7. The tube 31 projects through and in telescoping relation with

the central hollow rod 22 of the ram or plunger. Tubular member 4 has the hollow chamber 33 therein and provides a shoulder at 34 for the head 35 of the ram. A plurality of axially spaced apart hollow or tubular cylinders 36 are provided in the mandrel body 15, and pistons 37 are carried on the rod 22 to operate in the cylinders. A seal 38 is pocketed in the mandrel body 15 to wipe the rod 22 above the uppermost cylinder 36, and a seal 39 is similarly located below the lowermost cylinder.

As shown most clearly in Fig. 4-A, the tube 31 extends down into the piston rod 22 and is slidable over a tube 40 positioned within the lower portion of the hollow rod 22. The tube 31 has the closure plug 42 in the lower end thereof and is rigidly connected into the spider 41 having axial ports 42' therethrough. Peripherally, the spider 41 is connected into the hollow rod of the ram 43. Near the lower end of the tube 31, a port 44 registers with a lateral port 45 at the top of the tubing 40 when the members or elements of the assembled tool are in the retracted slip position shown in Figs. 1 and 2.

Nonregistry of the ports follows in sequence to the closing of the relief valve 30, as occurs during lost motion at the pin and slot connection 5 and 6. As soon as the central tubular member 4 rotates with the housing 1 and drill string 3, as when the left end of the slot 6 transmits rotary travel through the lug 5, the lower valve 46, comprising the ports 44 and 45, is closed, and further downward circulation of any fluid which may have been pumped from the top of the well is discontinued.

By reason of the splined connections 27 and 28, no relative rotation can occur between the mandrel and the piston rod, and when the spear or grapple 50 on the lower end of the piston rod is set by clockwise rotation of the drill string transmitted by the sleeve 1 through the lug 5 to the tubular stud 4 and through the lug 10 to the mandrel 14 and then through the splines 28 to piston rod 22, the reverse rotation of the connector sleeve 1 relative to the mandrel closes the relief valves for pressure actuation of the piston for setting the slips 17 and exerting pull on the spear 50. This spear is of a conventional type which has the slips 51 thereon to extend the slips 51 into gripping contact with an object to be lifted. Such object is usually a tubular member, termed a screen or liner, which has previously been installed in the well bore, or it can be any object 53 which it may be desired to retrieve, such as a piece of tubing which has been severed and lost in the well. The spear 50 is shown as only one type of element which may be installed on the piston rod 22 of the ram to engage an object, and the conventional grapple may be employed as well.

After the slips have been set, the spear engaged with the object to be lifted, and the valves closed, fluid pumped down the drill string 3 from the top of the well passes outwardly from the tubing 31 through the ports 54 therein (see Fig. 4A), and then outwardly through the ports 55 in the hollow rod 22, to the lower side 56 of each piston 37. This force should result in the lifting of the object 53 upwardly, and its disengagement from any binding formation or element, so that it can be raised with the tool and string to the top of the well bore and retrieved. The spline 28 on the piston rod 22 is below the seal 39 and supplements the splined connection 27 to cause the mandrel assembly 14 to rotate the rod 22 therewith without placing a strain on the links 19. Such rotation may be necessary in case the spear engaged object cannot be lifted, and it is necessary to cut away therefrom by rotation.

In order to release the pistons for downward motion when they are at the top of their strokes, as shown in Fig. 3, the drill string may be lowered a sufficient distance to permit the lug 10 to reach the level of the horizontal leg 12 in the J-slot. Drill string rotation in a clockwise or reverse direction from that which has set the tool, as

hereinabove described, will first, open the upper or release valve 30, and thereby equalize the fluid pressure within the tool and well bore, as the fluid within the tool, by the opening of the valve 30, is placed in communication with the well bore therearound.

As the pistons have moved upwardly, the collar 23 has compressed the spring 25, and now the release of pressure within the tool permits this spring 25 to urge the ram downwardly and permits the pistons 37 to force the fluid out from the cylinders 36 therebelow. Further rotation of the drill string after it has been lowered will place the lug 10 in the left-hand position in the leg 12, shown in Fig. 1, and the drill string can be raised to lift the assembly. The relative rotation and axial movement of the parts brings the ports 44 and 45 back into registry to open the lower valve 46, thereby re-establishing fluid flow and drainage through the tool.

Reversing the direction of mandrel rotation which has set the spear slips 51 in the object to be lifted, will result in releasing these slips from engagement with such object.

In construction, the seal member 60 may constitute a coupling 57 having flanges 58 on the ends thereof and a sealing member 59 thereinbetween. This seal is located to seal the annular space 61 between the tube 31 and the piston rod 22, and at an elevation above the valve 46 and below the ports 54 and 55 in the lowest position thereof. The seal 39 between the mandrel and ram comprises a seal member 62 which fits in the counterbore 63 in the mandrel and which is held in place by a seal ring 64.

Each piston 37 comprises a coupling member 65 connecting ram sections 66 and having a seal member 67 thereon to slidably contact the bore or wall 68 of the cylinder 36. Each partition member 56, as shown in Fig. 4, has a seal 69 thereon to contact the piston rod 22. Also the seal 38 fits in a counterbore 71 and is held in place by the hold-down ring 72. Additionally, the ram head 35 has the seal ring 74 therein to contact the tube 31 within the space 33. Furthermore, seal rings 75 and 76 are provided on either side of the valve 30. Thus, when the pistons are operating, these fluid tight connections insure that fluid pumped from the top of the well passes down the drill string and outwardly from the tubing 31 and piston rod 22 to the space beneath each piston 37.

To summarize an operating cycle, the tool is lowered on the end of the string 3, and the grapple 50 is engaged with the stuck object. The string and connector sleeve 1 are turned counterclockwise through a short arc within the limit of the lost motion pin and slots 5 and 6 to close the upper relief or by-pass valve 30 and direct pressure liquid through the lower, open valve 46 for washing over the stuck object. Should the washing be ineffective to loosen the binding formation, the liquid will have wetted or conditioned it for an easier release, and thereafter a further counterclockwise rotation of the sleeve 1 relative to the nonrotatably fixed and splined together mandrel 14 and grapple carrying piston rod 22 will carry along the central tubular stud 4 and dependent tube 31, sliding the mandrel suspension pin 10 in the horizontal leg 12 of the angle slot 11 to its intersection with the vertical slot 13. Such movement frees the mandrel for downward movement to expand the slips 17 and close the lower valve 41 so that pressure fluid no longer by-passes but is directed solely to the piston cylinders for exerting upward pressure on the under side of the pistons and downward pressure on the upper side of the bottom end walls of the cylinders to hold the slips expanded and to pull upwardly on the grapple as the spring 25 yields to accommodate sliding piston travel upwardly relative to the mandrel. After the stuck object is broken loose, the assembly can be lifted out of the well bore. Release of the slips 17, either after the stuck object is broken loose or for an additional washing and resetting, is effected by clockwise rotation of the coupling sleeve 1 to open the

5

upper relief valve 30 for by-passing pressure fluid away from the piston cylinder. Thereupon the force of the spring 25, either with or without a lowering of the string, will result in relative vertical travel of the pin 10 in the vertical slot 13 until the pin reaches alignment with the horizontal slot 12 for travel to the left-hand end of the slot 12. Retraction of the piston and return of the parts to the original position shown in Fig. 1 again opens the lower drain valve 46 for free fluid circulation through the tool. Control of the tool through the by-pass valve is primarily a function of angular position of the string and its turning in one or the other direction through prescribed arcs. The operator can easily regulate the tool by the simple expedient of short range turning increments.

In the modification shown in Figs. 9, 9-A, and 10, the upper portion of the tool is constructed similarly to the first modification, but in this modification the J-slot is omitted between the mandrel 14 and tubular member 4, and an inverted J-slot is supplied between the housing 20 of the slip assembly and the lower end of the mandrel 14. Thus counterclockwise rotation of the drill string 3 and the housing 1, first results in closing the release valve 30, as described hereinabove, and then results in the rotation of the tubular member 4 with the housing 1 and drill string 3. In this construction it should be noted that the mandrel 14 is connected to the central tubular member 4 by the threads 77, and consequently when the central member 4 rotates with the drill string, the mandrel 14 also rotates therewith.

In this modification, spear slips, not shown, but corresponding to the spear slips 51 shown in Figs. 1 and 2 engage upon the first rotation of the mandrel, since the ram rotates with the mandrel. This step occurs before the drill string is lowered to set the slip and close the lower valve 84.

Therefore, in order to set the slips 17 after the lug 10 has been rotated to the top of the vertical leg 13 of the inverted J-slot 11, it is necessary to lower the drill string and with it the tubular member 4 and mandrel 14 as the spring 25 bears on the ram collar 23 to hold the slip housing 20 against vertical movement with the mandrel.

As the tubing 31 is connected at 78 to the mandrel 14 so that the bore 7' thereof communicates with the bore 7 of the member 4, it is obvious that downward movement of the member 4 and mandrel 14 also results in the downward movement of the member 31. This member 31 has the bore 7' therein extending down to a point corresponding to some point below the port 54 in Fig. 4-A. From this point downwardly the member 31 is solid, and has the guide stem 80 on the lower end thereof to guide the member 31 within the seal 81 which fits in the valve body 82 to serve as the valve seat for the lower section 83 of the member 31. The lower valve 84 constituted by the relatively axially movable seal sleeve 81 and the lower plunger portion 83 having a slip fit within the seal sleeve 81 is therefore closed against fluid circulation or drainage through bottom of the tube 22 when the drill string 3, member 4, and mandrel 14 are lowered to set the slips and circulation out of the ports 45, and downwardly, is discontinued.

Thus, when the pump at the top of the well now operates, fluid can only be forced down the drill string into the bore of the central member 4 and bore 7' of the pipe 31, and out through the ports 54 and 55 to the cylinders 36 to exert pressure upon the lower surface 56 of the pistons 37. After the pistons are under fluid pressure a lift on the drill string will take the strain off the slips 17 and from this point the pistons alone are the lifting force.

To release this modification of tool it is only necessary to rotate the drill string opposite the setting direction to move the slot 6 upon the lug 5 to the position shown in Figs. 1 and 9. This opens the upper or release

6

valve 30 to permit the fluid pressure inside and outside of the tool to equalize. Then the drill string can be lifted to open the valve 84 and to locate the lug 10 in the horizontal leg 12 of the J-slot 11. Then further rotation in this direction will also rotate the ram and release the spear slips 51.

With this second, and preferred, modification of tool, a lift can be placed on the object to be lifted before the piston lifting force is added thereto, since the mandrel 14 can rotate the ram therewith so that the spear slips 51 can engage the object to be lifted before the slip members 17 are extended to grasp the well bore. When the slips 17 are set and pumping commences, the original lift and piston lift are additive forces.

Broadly, this invention includes a hydraulically operated pulling tool adapted to extend elements thereof to grasp an exterior surface, as a cased well bore to hold part of the tool against movement while pressure fluid moves another part thereof which has engaged an object to be pulled. This invention further includes such a tool which permits fluid to course therethrough, as when it is lowered into a cased well bore, and which is operable upon rotation and vertical motion actuated from the top of the well, to extend slip means to grasp the cased well bore, to engage the object to be lifted, and to close off the fluid flow therethrough.

What is claimed is:

1. With a tubular string rotatable in a cased well bore, the combination of, a housing connected to said string, a tubular member within said housing and connected thereto to extend therebelow and adapted to rotate therewith after limited rotation of said housing with relation thereto and adapted by said housing for fluid communication with said string bore, a mandrel connected to said tubular member and adapted to rotate therewith, and to move downwardly with relation thereto, after limited rotation of said member, a slip assembly including slip members connected to said mandrel to rotate therewith, a tubular ram extending around said member and having a collar thereon adapted to be supported within said assembly and having a lower portion slidably connected to said assembly to rotate therewith and extending therebelow to establish fluid communication between the bore thereof and said well bore and adapted upon rotation to engage an object to be pulled, resilient means around said ram and adapted to bear against said assembly to permit said mandrel to move downwardly relative thereto and against said slip members to extend said slip members outwardly into gripping contact with said well bore, upper valve means operable upon rotation of said housing with relation to said tubular member to control fluid communication between said tubular member bore and said well bore, lower valve means operable upon rotation of said tubular member with relation to said ram to control fluid communication between said tubular member bore and said ram bore, cylinder means in said mandrel, piston means on said ram operable in said cylinder means, seal means between said tubular member and said ram above said lower valve, and port means above said seal means in said tubular member wall and in said ram wall to admit fluid pumped down said string from the top of the well into said cylinder means to exert force beneath said piston means to lift said ram and said engaged object when said valve means are closed.

2. With a tubular string rotatable in a cased well bore, the combination of, a housing connected to said string, a tubular member within said housing and connected thereto to extend therebelow and adapted to rotate therewith after limited rotation of said housing with relation thereto and adapted by said housing for fluid communication with said string bore, a mandrel connected to said tubular member to rotate therewith, a slip assembly including slip members connected to said mandrel, means adapting said mandrel to rotate with relation to said slip assembly and to move downwardly with relation

7

thereto, a tubular ram extending around said member and having a collar thereon adapted to be supported within said assembly and having a lower portion slidably connected to said assembly to rotate therewith and extending therebelow to establish fluid communication between the bore thereof and said well bore and adapted upon rotation to engage an object to be pulled, resilient means around said ram and adapted to bear against said assembly to permit said mandrel to move downwardly relative thereto and against said slip members to extend said slip members outwardly into gripping contact with said well bore, upper valve means operable upon rotation of said housing with relation to said tubular member to control fluid communication between said tubular member bore and said well bore, lower valve means operable upon downward movement of said tubular member with relation to said ram to control fluid communication between said tubular member bore and said ram bore, cylinder means in said mandrel, piston means on said ram operable in said cylinder means, seal means between said tubular member and said ram above said lower valve, and port means above said seal means in said tubular member wall and in said ram wall to admit fluid pumped down said string from the top of the well into said cylinder means to exert force beneath said piston means to lift said ram and said engaged object when said valve means are closed.

3. In a pulling tool of the character described, a cylin-

8

der member, a piston slidable in the cylinder chamber and having a downwardly projecting piston rod nonrotatably keyed to the cylinder member, means on the lower end of the rod for coupling with an object to be pulled, an expansible slip carried by the piston rod, a slip expander on the cylinder member operable to set the slip upon downward movement of the cylinder member, a cylinder suspension member telescopically fitted to the cylinder member, a load carrying pin projecting from one of the members into an angle slot in the other member, one leg of the angle slot being horizontal for cylinder suspension through said pin in lifted slip retracted position, and the other leg being vertical for relative axial pin movement in the downward travel of the cylinder to slip expanded position, said suspension member having a passage in constant communication with the piston cylinder, a string connector through which pressure fluid is supplied to said passage and which has a rotary lost motion connection with said suspension member, said connector and suspension member constituting a rotary valve controlling alignment of passage communicating lateral ports therethrough.

References Cited in the file of this patent

UNITED STATES PATENTS

999,731	Alten et al.	Aug. 8, 1911
2,377,249	Lawrence	May 29, 1945
2,537,413	Lawrence	Jan. 9, 1951