

Oct. 18, 1966

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3,279,543

WELL TOOL FOR REMOVING SAND

Filed Jan. 30, 1964

3 Sheets-Sheet 1

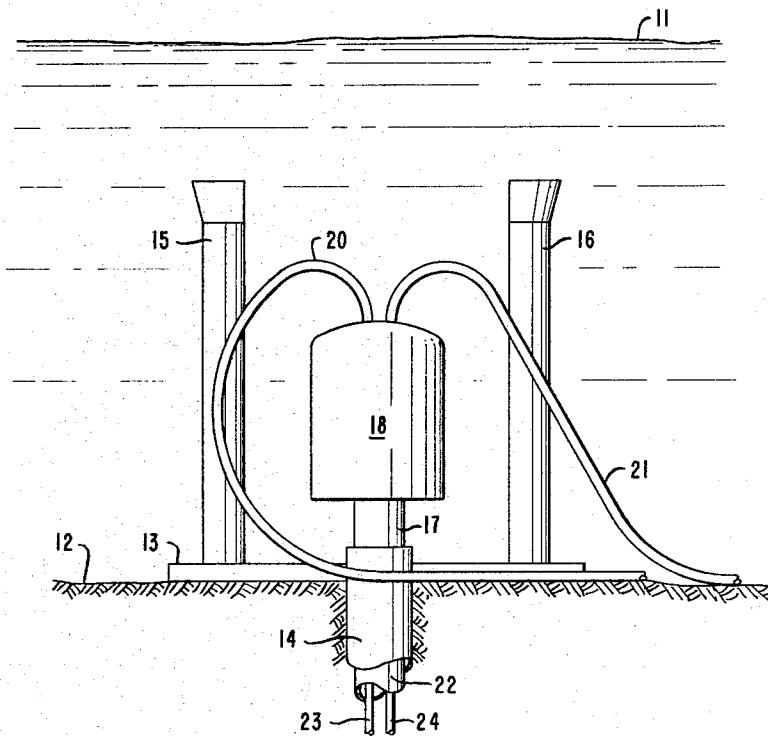


FIG. 1

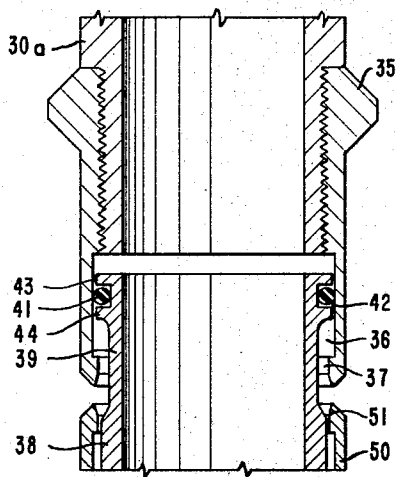


FIG. 5

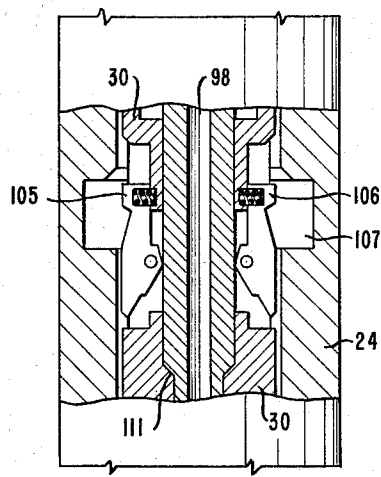


FIG. 4

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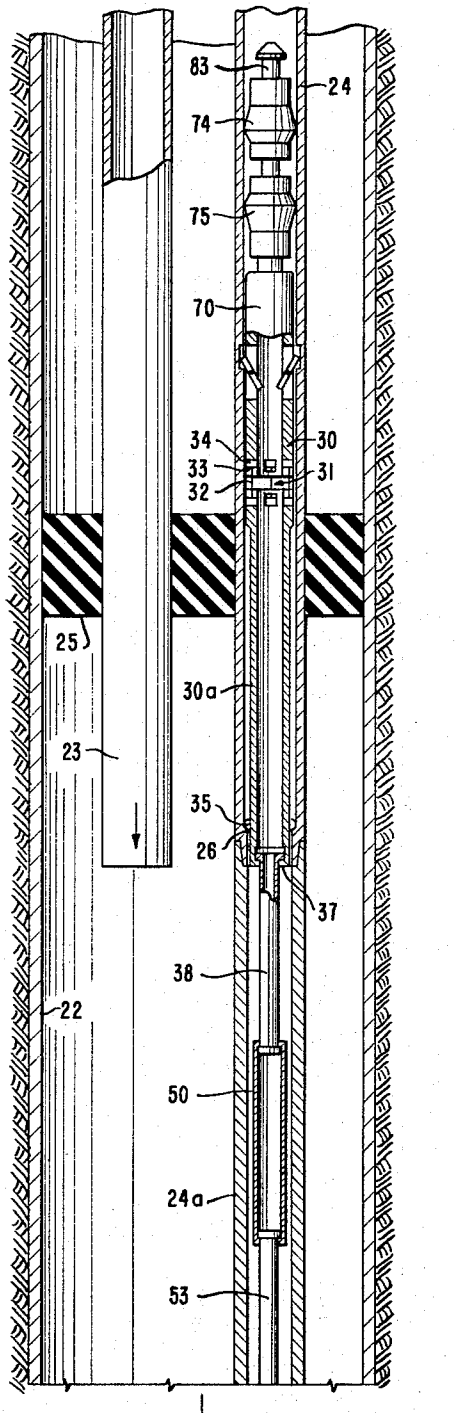


FIG. 2A

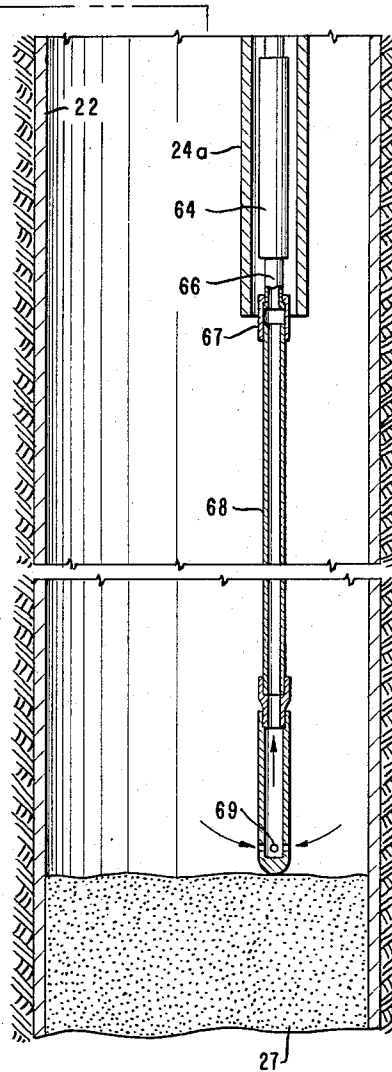


FIG. 2B

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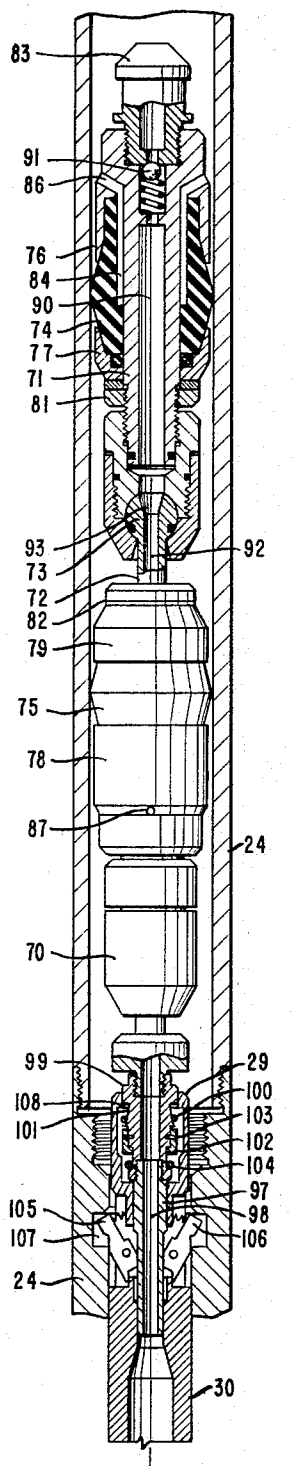


FIG. 3A

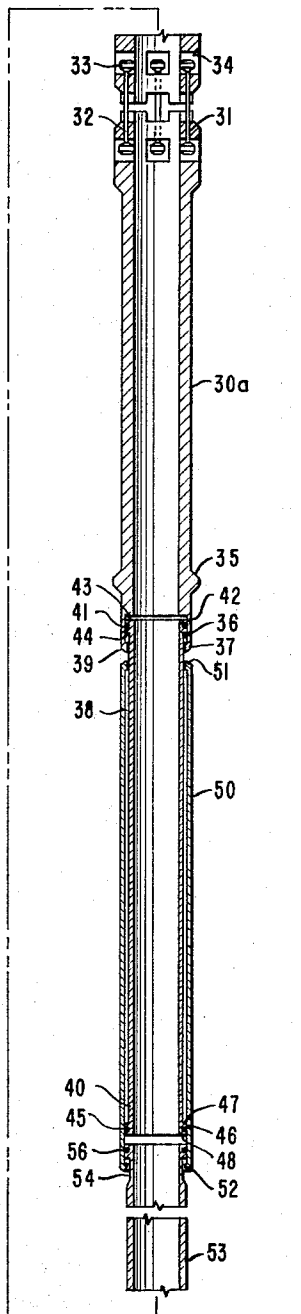


FIG. 3B

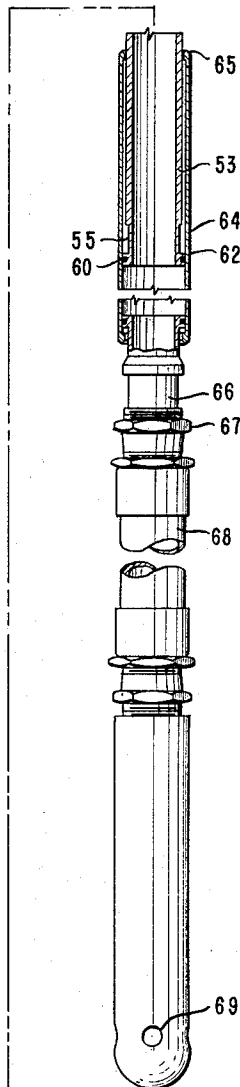


FIG. 3C

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3,279,543

WELL TOOL FOR REMOVING SAND

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5 Claims. (Cl. 166—155)

This invention relates to a sand-removal well tool adapted to be pumped up or down a string of tubing positioned in a well and pertains more particularly to a sand-removal tool adapted to be pumped down a well tubing to engage and connect to the lower end of the tubing during sand-washing operations and subsequently be returned to the surface.

A recent development in the oil industry is the drilling and completion of wells in offshore locations where the wellhead assembly and production control units are positioned beneath the surface of a body of water and preferably close to the bottom of the body of water. With wellhead assemblies positioned on an ocean floor, a hazard to the navigation of boats in offshore water is removed. Additionally, considerable savings are realized in that it is not necessary to erect a protective stationary platform around the wellhead in the manner in which they are employed to protect well casing and wellhead assemblies extending above the surface of the water. It has also been found necessary to position a wellhead assembly on the ocean floor in water depths where it is not feasible to erect the stationary platform around the wellhead assembly.

However, the placement of wellhead assemblies on the ocean floor raises a new set of problems with regard to carrying out workover operations, maintenance and other operations in a completed well. Major workover operations call for the use of a barge positioned on the surface of the water above the well together with equipment for going down and entering the wellhead assembly and the tubing or casing string connected thereto, and in some circumstances may result in the removal of the entire wellhead assembly to the surface during workover operations. In order to carry out some of the more simple workover or maintenance operations, such as the removal of a valve, the cleaning of paraffin from a tubing string, the cleaning of sand from the well casing, etc., it has been necessary to develop an entirely new line of well tools which can be pumped through a production tubing string from some remote location, oftentimes a mile or more from the well, and enter the well, passing through one or more curved sections outside the well and then down the tubing string therein to be subsequently positioned therein for carrying out some preselected operation. After completing the operation, the tool in the tubing string within the well is subsequently removed, generally and preferably by reverse circulation of fluid within the tubing of the well.

One of the most pressing problems in wells in many areas is the periodic removal of sand which accumulates in the well below the tubing. This problem is further complicated where the wellhead is located on the ocean floor since the sand-removal tool must be designed so that it can be pumped through a tubing string. In prior devices an elongated hose member has been pumped down the well string for sand-washing purposes. Since a flexible hose can easily buckle and otherwise foul, it has been

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necessary for prior art devices to incorporate complicated systems for keeping the hose stiff enough to pass through the tubing string without fouling and yet flexible enough to pass curved sections of the tubing string. Another disadvantage of using an elongated hose in sand removal operations is the fact that only a small degree of slack can be provided in the hose, making a given hose capable of removing sand through only a limited vertical range. This necessitates the time-consuming operation of pumping the tool back through the tubing string for the installation of new hose sections as the sand level falls when the sand is washed from the bottom of the wellbore. Furthermore, as the length of the hose increases, it becomes exceedingly difficult to pump it through the tubing string. The subject invention provides an inexpensive solution to these and other problems encountered in the use of prior art sand removal tools.

Broadly, the present invention provides a sand removal tool adapted to be pumped down a well tubing string, to engage a suitable stop, typically at the lower end thereof, during sand removal operations, and to be subsequently disengaged from the stop in the tubing string and circulated up the tubing string at the end of the wash-out operations. The tool includes a plurality of tubular members which are sequentially joined to each other in telescoping relation so that as sand is washed from the bottom of the wellbore and the sand level falls, the tool will extend deeper into the bore. The invention thus provides a device capable in many cases of removing all the sand from a wellbore in a single operation; however, when the total depth of sand significantly exceeds the extensibility range of the telescoping tubular sections, the tool may be pumped out for the substitution of a longer telescoping assembly.

The advantages of this invention will be understood from the following description taken with reference to the drawing, wherein:

FIGURE 1 is a schematic elevational view illustrating a wellhead assembly positioned on an ocean floor;

FIGURES 2A and 2B are longitudinal sectional views respectively of the upper and lower juxtaposed portions of a well, showing one arrangement of a well in which the apparatus of the present invention has been installed, the sand-removal tool being shown in extended condition;

FIGURES 3A, 3B and 3C are longitudinal sectional views, partly in elevation, of juxtaposed portions of the sand removal apparatus of the present invention, shown in greater detail and to an enlarged scale, the tool being shown in contracted condition;

FIGURE 4 is an elevation, taken in partial longitudinal cross-section of a latching device in its inoperative position, showing an enlarged probe for releasing the latch; and

FIGURE 5 is an exploded view of a telescoping joint connection used in the tool.

Referring to FIGURE 1 of the drawing, a wellhead assembly is shown as being positioned below the surface 11 of a body of water and preferably on the ocean floor 12. The wellhead apparatus comprises a platform 13 secured to the top of a conductor pipe or surface casing 14 which in turn extends into the earth below the body of water and is preferably cemented therein in a conventional manner. The wellhead assembly may also be provided with two or more vertically positioned guide columns 15 and 16 which are fixedly secured at their

lower ends to the platform 13. A well casinghead 17 is mounted on the top of the conductor pipe 14 and a control equipment housing 18 closes the top of the casinghead and/or any casing and tubing suspension equipment employed on the wellhead assembly, as well as the various control valves and other control equipment normally used on the top of a well of this type.

Emerging from the housing 18 is a pair of flowlines 20 and 21 which preferably bend in long sweeping curves from a vertical position down to a substantially horizontal position so that they can run along the ocean floor to a remote location where fluid from the well, and normally from other wells, is collected and metered and treated. Such a collection station may be several miles away. During the production of the well, normally only one of the flowlines 20 or 21 is employed in transporting fluid away from the well. The well may be provided with one or more strings of well casing 22 suspended within the conductor pipe 14. The flowlines 20 and 21, in the particular installation illustrated, are in communication with and form continuations of a pair of tubing strings 23 and 24 depending within the well. However, in other installations utilizing a single tubing string, the second flow line may be in communication with the annular space between the tubing string and the adjacent wellhead; further, more than two flow lines may be used.

In FIGURE 2A the two tubing strings 23 and 24 contained within the well casing 22 are shown as being secured at their lower ends to a suitable packer shown diagrammatically at 25. At least one and preferably both of the tubing strings 23 and 24 have an annular seating shoulder 26 formed on the inner wall thereof for stopping any tool of slightly larger diameter from passing the shoulder 26 and dropping out the end of the tubing string. The well casing 22 is shown (FIGURE 2B) as being closed at its lower end by an accumulation of sand 27.

In order to carry out sand removal operations within a well casing of a well which has been drilled and completed underwater, a sand-removal tool in accordance with the present invention is provided. The sand-removal tool of the present invention employs a two-piece tubular mandrel comprising members 30 and 30a (FIGURE 2A) which are connected together preferably by flexible joint 31. As best shown in FIGURE 3B, joint 31 comprises four pins 32 having enlarged heads 33 on each end which fit loosely into cut-out spaces 34 on the ends of mandrel portions 30 and 30a. The flexible joint 31 facilitates passage of the two-piece mandrel through curved sections of the tubing string. The lower portion of member 30a is provided with a circumferential stop element 35 which is large enough to contact and be stopped by seating shoulder 26 located inside the tubing string 24.

As further shown in FIGURE 3B and the exploded view of FIGURE 5, the lower end of mandrel member 30a has an internal annular recess 36 which terminates in an inward shoulder or flange 37 at the lowermost end. A first tubular member 38 is shown extending from the lower end of mandrel member 30a with reduced external-diameter portions 39 and 40 near each of its ends. An O-ring sealing member 41 is shown in the space 42 formed by the annular shoulder portions 43 and 44 at the upper end of tubular member 38. Another O-ring 45 is shown in space 46 formed by shoulder portions 47 and 48 at the lower end of tubular member 38. A second tubular member 50 is shown outside first tubular member 38 and in concentric relation thereon. Second tubular member 50 is free to slide along the longitudinal axis of first tubular member 38 until the inwardly directed shoulder 51 comes in contact with shoulder portion 47 of the first tubular member 38. Another inwardly directed shoulder 52 is shown on the lower end of second tubular member 50.

Third tubular member 53 extends from the lower end of second tubular member 50 and is identical in construction to first tubular member 38, having, near its end, re-

duced diameter portions 54 and 55 and sealing means, such as O-rings 56 and 60. A fourth tubular member 64 is shown outside third tubular member 53 and in concentric relation thereto. Fourth tubular member 64 is identical to second tubular member 50 and is free to slide downwardly along the longitudinal axis of the third tubular member 53 until the inwardly directed shoulder 65 thereof contacts shoulder portion 62 located at the lower end of third tubular member 53. By providing a telescoping arrangement between tubular elements 38, 50, 53 and 64, as shown, it is possible to provide an extension means which can be extended to almost twice its collapsed length. This extendible feature provides a tremendous advantage not found in known sand removal tools and allows deep deposits of sand to be removed in a single operation.

The tubular members 38, 50, 53 and 64 each measure about 11 inches and any number desired may be connected together although only four have been illustrated. It is to be noted that the length of the tubular members is dependent only upon the radius of curvature and the internal diameter of any bend in the flowline or tubing. Normally, a series of tubular members such as 38, 50, 53 and 64 will remain in the collapsed position, shown in FIGURES 3B and 3C, when being passed through a flowline leading to the wellhead. However, even if the members assume the full extended position, they will knuckle or flex curved sections of the flowline. This flexing action is possible because the extreme ends of outer tubular members 50 and 64 are free to tilt or knuckle in the reduced external diameter portions 39, 40 and 54, 55 of inner tubular members 38 and 53, respectively.

The lower end of fourth tubular member 64 is connected to a short tubular member 66, which in turn is threadedly connected at 67 to a flexible, small-diameter hose 68. Flexible hose 68 may vary in length and may be made of any desired material but a suitable rubber or plastic material is preferred to make the apparatus flexible enough to pass around a short-radius bend. The device could be operated without the use of hose 68, but the added length and mass makes its use preferable. To keep the telescoping sections in proper alignment, when in the washing position, it is desirable, though not necessary, to provide some form of guide member such as the tubular extension 24a. The extension 24a is of greater length than the extended telescoping sections and insures that the O-rings such as 41 and 45 properly seal.

In order to propel the mandrel or body member 30, its telescoping tubular members 38, 50, 53 and 64, and the attached hose 68, a tool carrier of any suitable type may be connected to the upper end of the mandrel body 30. A preferred design of the tool carrier is shown in U.S. Patent 3,052,302 to Lagucki. The tool carrier (FIGURE 3A) comprises a central mandrel comprising sections 71 and 72, preferably connected together by a flexible ball-in-socket joint 73, so as to facilitate movement of the tool carrier in curved sections of a well tubing or pipe. Mounted on the central mandrel 71, 72 is a pair of sealing elements or packers 74 and 75 which are held thereon by suitable sealing-element or packer-retaining cups or rings 76 and 77, 78 and 79, respectively. The sealing elements 74 and 75 and their retaining cups 76, 77, 78 and 79 are held in position on the mandrel 71, 72 by retaining nuts 81 and 82.

Since the possibility always exists that any tool attached to the tool carrier may become stuck in a well, the tool carrier is preferably provided with a fishinghead 83 whereby a retrieving tool (not shown) may be run through the tubing string 23 to latch onto the fishinghead 83, thereby permitting removal of the tool carrier and the mandrel body 30, 30a, telescoping-tubular members 38, 50, 53 and 64, and the hose 68 connected thereto. The retrieving tool may take the form of another tool carrier having latching means carried at its lower end to connect onto the fishinghead 83 of the tool carrier stuck within the

well. As illustrated, the packer-retaining elements or cups 76 and 77 surround the ends of the packer or sealing element 74 while at the same time being axially spaced from each other on the central mandrel 71 so that the packer element 74 is against or may be expanded against the inner wall of a tubing string 24 to form a seal thereagainst. Preferably, the sealing elements 74 and 75 are formed having an internal diameter slightly larger than that of the mandrel 71, 72 so that undercut portions or annular spaces 84 are formed between the mandrel and the sealing element.

Fluid ports 86 and 87 are provided through the walls of the packer-retaining cups 76 and 78 near the closed end thereof so that fluid passageways are formed through the packer-retaining cups and communicate between the spaces outside the packer and annular spaces 84. The packers or sealing elements 74 and 75 are made of any suitable inflatable, resilient material, such as rubber, synthetic rubber, rubberized fabric, or certain plastic materials which may be expanded under the application of a pressure fluid. A portion of the sealing element 74 in contact with the inner wall of the tubing string may have a thickened cross-section so as to provide for some wear on the seal as it is propelled through the tubing. In addition, the sealing element 74 may be beveled to substantially a point as illustrated, if desired.

During the use of the tool carrier of FIGURE 3, a pressure fluid enters ports 86 and flows into the annular space 84 within the packer element 74 so that the packer element 74 is forced against the inner wall of the tubing string, thus causing the packer element to act as a piston seal, whereby the tool carrier is forced downwardly through the tubing string by application of continuous pressure from above. This action takes place since a pressure differential exists across the upper sealing element 74 whereas no pressure differential exists across the sealing element 75 on downward travel of the tool carrier, since the fluid pressure on either side of the lower sealing element is the same and there is therefore no tendency for the sealing element 75 to expand against the wall of the tubing. Thus, it may be seen that, on the downward travel of the present tool carrier, the upper sealing element maintains a tight fit against the tubing at all times, while the lower sealing element 75 merely acts as an inoperative piston which would not contact the tubing wall with any force to form a seal thereagainst and hence would not be subject to wear as the carrier passes downwardly through the tubing string.

In returning a tool carrier, with or without its accompanying sand removal body member 30, 30a, telescoping tubular sections 38, 50, 53, and 64, and hose 68, to the top of a well, circulation of the driving fluid in the tubing string 23 is reversed so that the pressure fluid moves downwardly through the tubing string 23 and upwardly through the string 24. Thus, the action of the sealing elements 74 and 75 is reversed, with the sealing element 75 acting as the piston and the sealing element 74 acting as a follower. It is apparent that the present tool carrier would be operative even if the locations of the sealing elements 74 and 75 were reversed.

The tool carrier is also provided with a longitudinal flow passageway, preferably in the form of an axial bore 90 in the upper mandrel section 71. A spring-loaded check valve 91 is preferably positioned in the bore 90 within the tool carrier, the valve 91 being adapted to open preferably at a greater pressure than that needed to expand the sealing element 74 against the wall of the tubing. The lower mandrel section 72 is also provided with a bore 92 which communicates with the bore 90 through a flow passage or bore 93 in the flexible joint 73. The flexible joint 70 in turn is provided with a flow passage (not shown) which communicates with the passage 92 so that the interior of the body members 30 and 30a and the hose 68 are subjected to upstream pressure within the tubing string when the pressure fluid passes the check valve 91.

In running the sand-removal body members 30 and 30a, the telescoping tubular sections 38, 50, 53 and 64, and the hose 68 into the well, it is apparent that the tool carrier may be merely in free contact or pushing abutment with the top 29 of the housing 30. However, preferably the running tool or its flexible joint 70 has attached to the lower end thereof a suitable latching tool adapted to be disconnected from the mandrel body 30 after the mandrel body has been run into place on the stop element 35. A preferred form of latching device comprises a probe-like cylindrical element 97 having an axial fluid passageway 98 therethrough. The probe-like element 97 is threadedly secured to the bottom of a running and pulling mechanism in the form of a generally cylindrical body having a split spring locking ring 100 carried on a downwardly and outwardly tapered shoulder 101 formed on the outside of the mechanism. Just below the tapered shoulder 101 is a slidable ring 102 pinned in place by shear pins 103 to the body 99 of the mechanism. A retaining ring 104 is provided for holding the shear pin ring 102 on the mechanism after the shear pins 103 have been sheared. The diameter of the shear pin ring 102 is slightly greater than that of the tapered shoulder 101 so that on being forced downwardly the locking spring ring 100 will contact the top of the shear pin ring 102. The probe 97 is designed to slip through a central bore in the body member 30 to engage latching dogs 105 and 106 pivotally mounted on the housing 30 for radial outward movement into an annular recess 107 formed within tubing string 24. The latching dogs 105 and 106 are pivoted at points above the lower ends thereof, which permits the inner surface of the lower end of each dog to contact the outer surface of the probe 97 so that the dogs are upwardly directed.

In the use of the apparatus of the present invention, the entire apparatus comprising the tool carrier with the sealing elements 74 and 75, the latching device 99, body member 30, telescoping tubular sections 38, 50, 53 and 64, and the hose 68 are connected together and inserted into the flowline 21 (FIGURE 1) at a distant point, such for example, as a production platform or from an installation on shore. A source of pressure fluid (not shown) is connected to the flow line 21 in back of the tool which has been inserted in the line, and the fluid is pumped through the line 21 in back of the tool carrier and sand removal apparatus of the present invention until it has passed over the curved section of the flowline and enters the wellhead assembly where it passes down the tubing string 24. The tool carrier and its sand removal body members 30 and 30a, telescoping tubular sections 38, 50, 53 and 64, and hose 68 continue to pass down through the tubing string 23 until the body member 30a seats when stop element 35 comes into contact with landing shoulder 26, which action is ascertained at the surface by a build-up of pressure in the line. At this time, the tubular elements or members 50 and 64 begin to extend telescopically and the flexible hose 68 drops out the end of tubing string 24 and contacts the sand 27 which has accumulated at the bottom of the well. During the pumping operation the check valve 91 (FIGURE 3A) in the top of the tool carrier opens, allowing pressure fluid to be pumped through the tool carrier latching device and into the hose section 68. At the time the stop element 35 of body member 30a seats on the internal shoulder 26 of tubing string 24, the latching dogs 105 and 106 which are spring-loaded to expand outwardly, expand into annular recess 107 locking the body member 30 in the tubing string 24.

Fluid flows down the tubing 24 through the apparatus and hose, to be discharged out openings 69 (FIGURE 3B) in the lower end of the hose and is circulated up the other tubing string 23 or up the annular space between the tubing string 24 and the well casing 22 in the event that a second tubing string is not employed within the well. Sand removal from the casing may be carried out

by continued circulation of fluid down tubing 24 and up tubing 23, with entrainment of sand in the fluid. However, sand removal may take place in the following manner. After the fluid circulation path has been established, reversed circulation is brought about in a conventional manner with the fluid flowing down the tubing string 23 (as shown by the arrows in FIGURE 2B), into the ports 69 at the end of the hose 68, and then up through the apparatus and tubing string 24.

On reversing circulation so that the pressure fluid flows down tubing 23 and up tubing 24, the running tool having sealing elements 74 and 75 and the probe 97 are extracted from the body member 30 in the following manner as the body member 30 is held in position by dogs 105 and 106. Upward pressure of fluid keeps valve 91 closed and forces the body 99 of the latching mechanism (FIGURE 3A) upwardly until the locking spring ring 100 contacts a shoulder 108 at the top 29 of the body member 30. As the body 99 of the latching mechanism continues to move upwardly, the split ring 100 is forced down the tapered shoulder 101 until it contacts the top of the shear-pin ring 102. An increase in the fluid pressure causes the shear pins 103, which are preferably bronze or some other soft metal in this operation to shear and the shear pin ring 102 is prevented from travelling upward, allowing the split ring 100 to move downwardly relative to the tapered shoulder 101 and contract to a smaller diameter below the shoulder. The ring 102 is then free to move upwards out of the top 29 of the body member 30, when engaged by the ring 104. With the latching assembly 99 and probe 97 free of the housing 30, these elements move upwardly through the tubing 24 with the tool carrier where this portion of the apparatus can be retrieved at, for example, a well platform manifold.

Continued reverse circulation of fluid down tubing 23 and up tubing 24 entrains the sand 27 which enters the lower end of the hose 68 and is circulated to the surface. As the sand build-up 27 erodes away the pull of gravity causes telescoping tubular members 50 and 64 to further extend downwardly, thereby keeping the hose 68 in contact with the sand until the sand deposit 27 has been removed. It is to be understood that the tool carrier need not have bore 90 and valve 91 if the apparatus is operated in this fashion.

When the fluid returning to the surface through tubing 24 indicates that all the sand has been removed, the body members 30 and 30a and telescoping tubular sections 38, 50, 53 and 64 with the hose 68 may then be removed by pumping a tool carrier down the tubing string 24, the tool carrier being provided with an engaging tool at its lower end for latching onto the body member 30 and retracting its locking dogs 105 and 106. As shown in FIGURE 4, the only difference between the retrieving mechanism and that employed to place the body member in place originally is that a large-diameter probe 111 is employed so that the locking dogs 105 and 106 of the housing member 30 are retracted out of the annular recess 107. Also, in the case of retrieving the tool, the shear pins 103 (FIGURE 3A) are made of steel instead of a soft metal so that they will not shear. Thus, when circulation is reversed so that the locking spring ring 100 is forced upwardly in contact with shoulder 108, a continued application of fluid pressure raises the entire body member with its retracted dogs 105 and 106 (FIGURE 4) out of the tubing string 24 along with the tubular telescoping members and the hose, and the entire apparatus is circulated up the tubing string 24 where it may be retrieved. It is to be understood that the normal diameter of the split ring 100 is of a size to contact the shoulder 108 when moved against it in an upward direction. At the same time the split ring 100 may be contracted sufficiently to pass shoulders 108 on moving downwardly therethrough.

I claim as my invention:

1. A sand-removal well tool adapted to be pumped

down a pipe string within a well, said string of pipe having a lower open end and shoulder means positioned therein to prevent the passage of a well tool therethrough, said well tool comprising:

- (a) a body member of a diameter small enough to pass through the pipe string in the well and adapted to be stopped by said shoulder means of said pipe string;
- (b) a plurality of tubular members connected to the lowermost end of said body member in fluid communication therewith;
- (c) means joining said plurality of tubular members sequentially to each other in telescoping relation so that the tubular members may be longitudinally collapsed and extended; and
- (d) an elongated section of flexible hose secured to the lowermost end of said plurality of tubular members and in fluid communication therewith.

2. A sand-removal well tool adapted to be pumped down a pipe string within a well, said string of pipe having a lower open end and shoulder means positioned therein to prevent the passage of a well tool therethrough, said well tool comprising:

- (a) a body member of a diameter small enough to pass through the pipe string in the well and adapted to be stopped by said shoulder means of said pipe string;
- (b) a pumpable tool carrier adapted to pass through the pipe string and be connected and disconnected to the top of said body member;
- (c) retractable latching means carried by said body member for connecting to the pipe string near the lower end thereof;
- (d) a plurality of tubular members connected to the lowermost end of said body member in fluid communication therewith;
- (e) means joining said plurality of tubular members sequentially to each other in telescoping relation so that the tubular members may be longitudinally collapsed and extended; and
- (f) an elongated section of flexible hose secured to the lowermost end of said plurality of tubular members in fluid communication therewith.

3. A sand-removal well tool adapted to be pumped down a pipe string within a well, said string of pipe having a lower open end and shoulder means positioned therein to prevent the passage of a well tool therethrough, said well tool comprising:

- (a) a body member of a diameter small enough to pass through the pipe string in the well and adapted to be stopped by said shoulder means of said pipe string;
- (b) a plurality of tubular members connected to the lowermost end of said body member in fluid communication therewith;
- (c) means joining said plurality of tubular members sequentially to each other in telescoping relation so that the tubular members may be longitudinally collapsed and extended; and
- (d) a guide means connected to the lower end of said pipe string for limiting lateral movement of said tubular members upon extension thereof, wherein said guide means has a length at least as great as the aggregate length of a plurality of said tubular members when extended.

4. A sand-removal well tool adapted to be pumped down a pipe string within a well, said string of pipe having a lower open end and shoulder means positioned therein to prevent the passage of a well tool therethrough, said well tool comprising:

- (a) a body member of a diameter small enough to pass through the pipe string in the well and adapted to be stopped by said shoulder means of said pipe string;
- (b) a plurality of tubular individually telescoping sections connected end to end and having the end of one

of said telescoping sections connected to the lower end of said body member; and,

(c) flexible joint means interconnecting adjacent tubular telescoping sections to permit said tool to pass through curved sections of said string of pipe. 5

5. The well tool as defined in claim 4 wherein each of said telescoping sections comprise inner and outer telescoping tubular members including cooperating flange means at the ends of said tubular members which limit the extension of said members, said flange means being of a diameter to permit limited axial deflection of said tubular members when said members are in an extended position.

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