Nov. 2, 1965 P. S. SIZER 3,215,203

APPARATUS FOR MOVING A WELL FLOW CONDUCTOR INTO OR OUT OF A WELL

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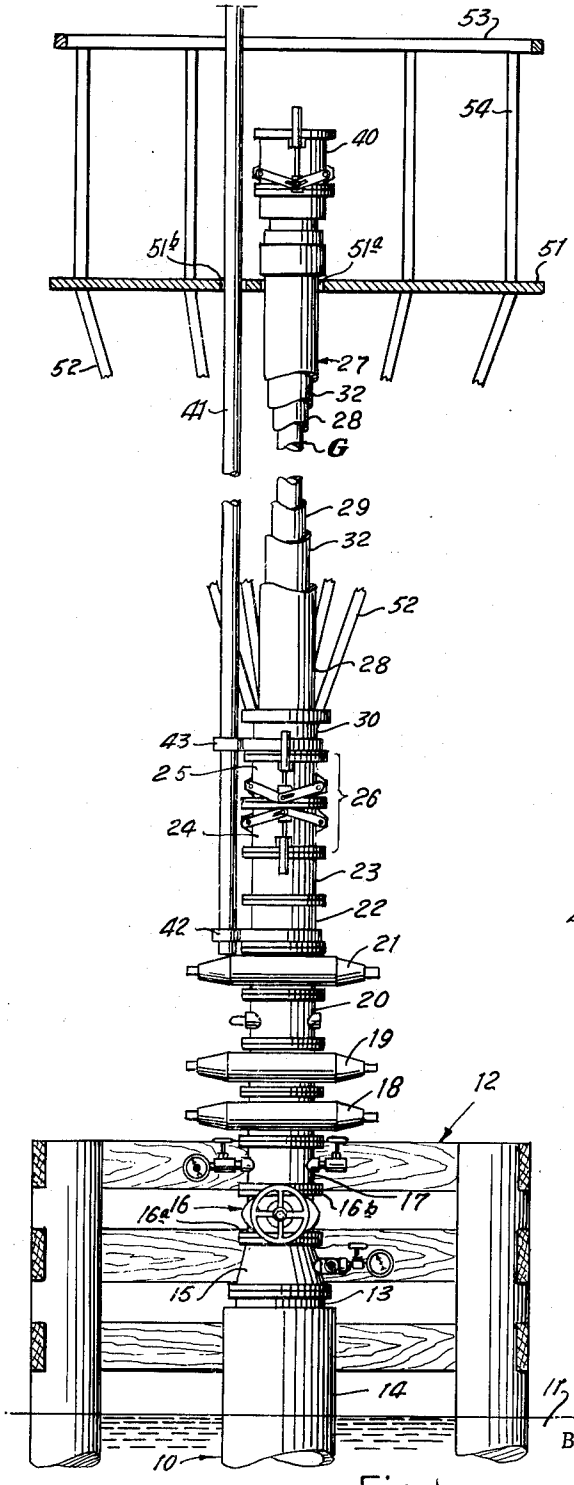


Fig. 1A

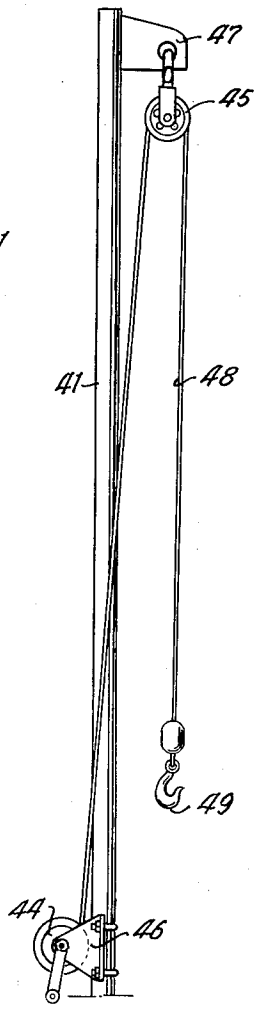


Fig. 1B

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Nov. 2, 1965 P. S. SIZER 3,215,203

APPARATUS FOR MOVING A WELL FLOW CONDUCTOR INTO OR OUT OF A WELL

Filed April 17, 1961 5 Sheets-Sheet 2

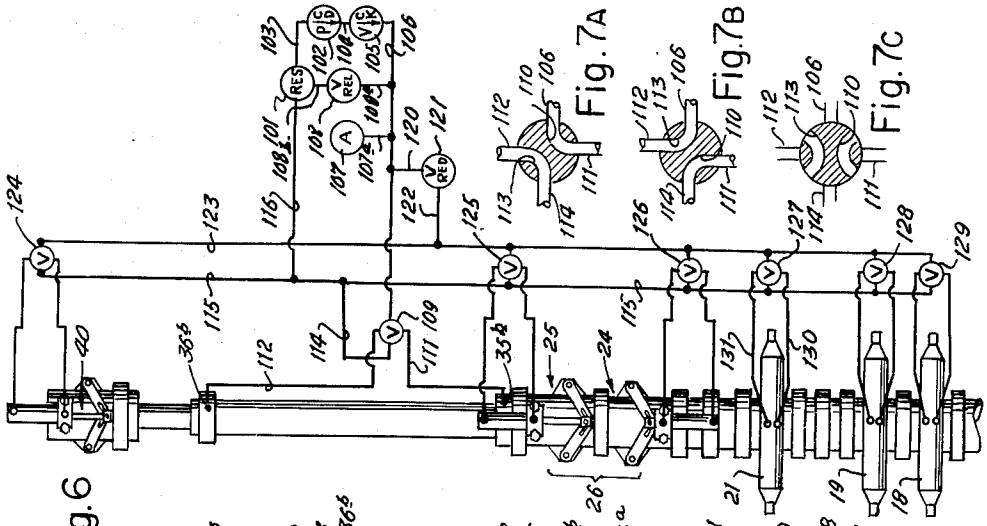


Fig. 7A Fig. 7B Fig. 7C

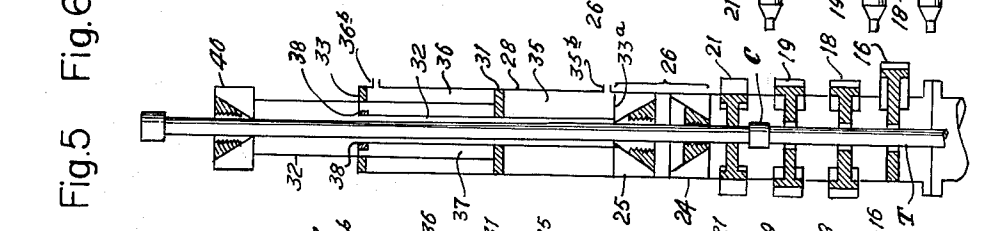


Fig. 6

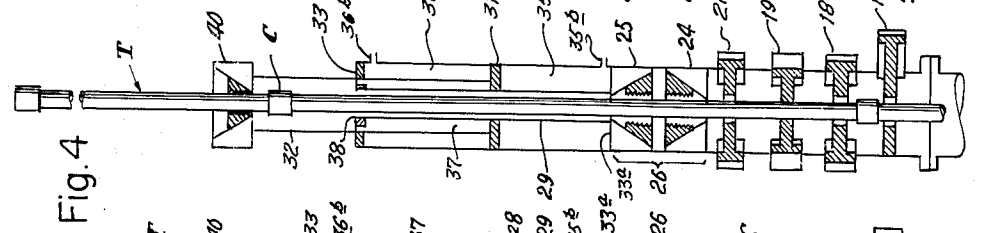


Fig. 5

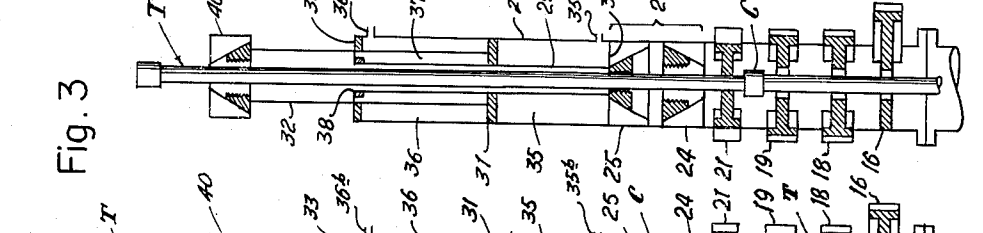


Fig. 4

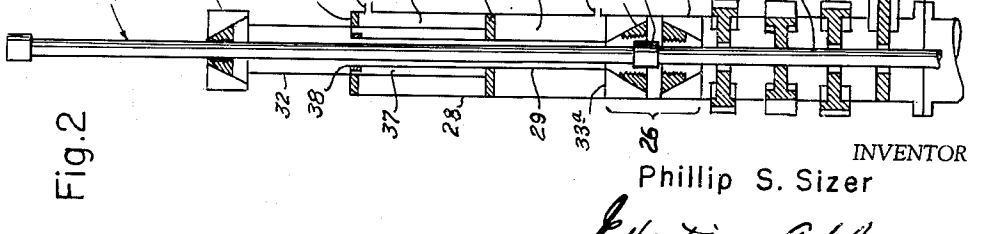


Fig. 3

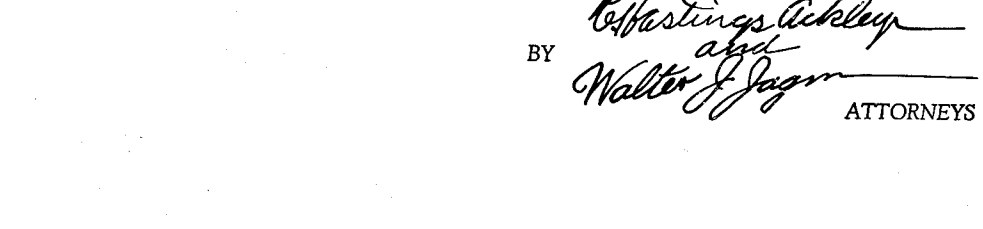


Fig. 2

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Nov. 2, 1965 P. S. SIZER 3,215,203

APPARATUS FOR MOVING A WELL FLOW CONDUCTOR INTO OR OUT OF A WELL

Filed April 17, 1961 5 Sheets-Sheet 3

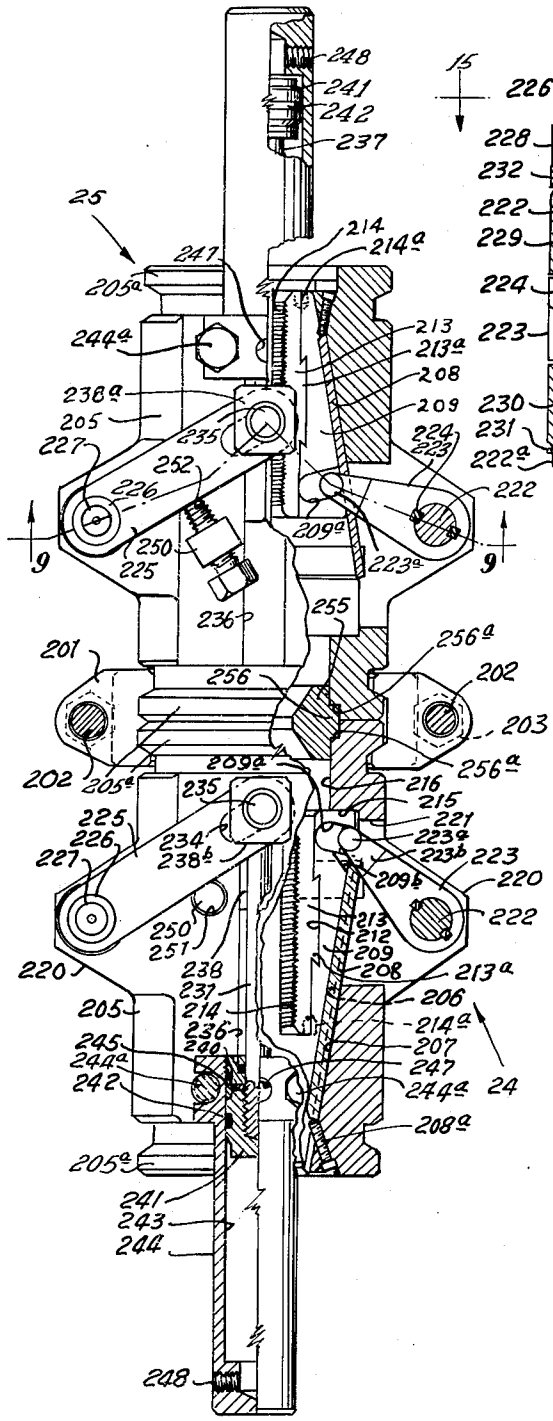


Fig 8

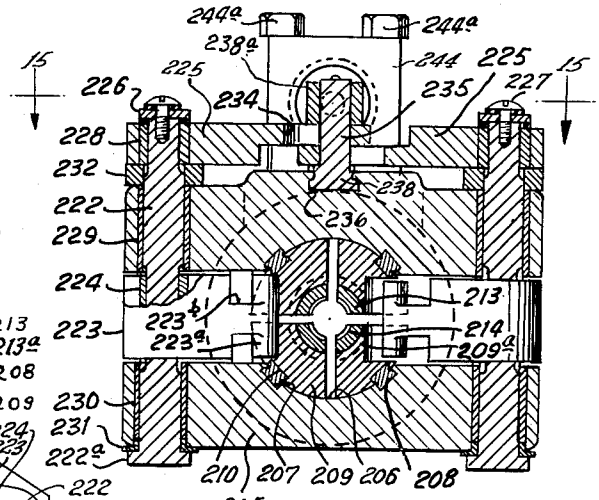


Fig.9

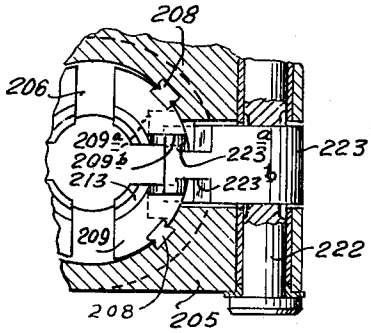


Fig.10

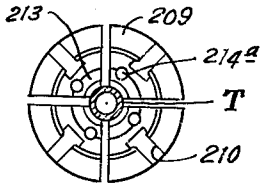


Fig.11

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Nov. 2, 1965 P. S. SIZER 3,215,203

APPARATUS FOR MOVING A WELL FLOW CONDUCTOR INTO OR OUT OF A WELL

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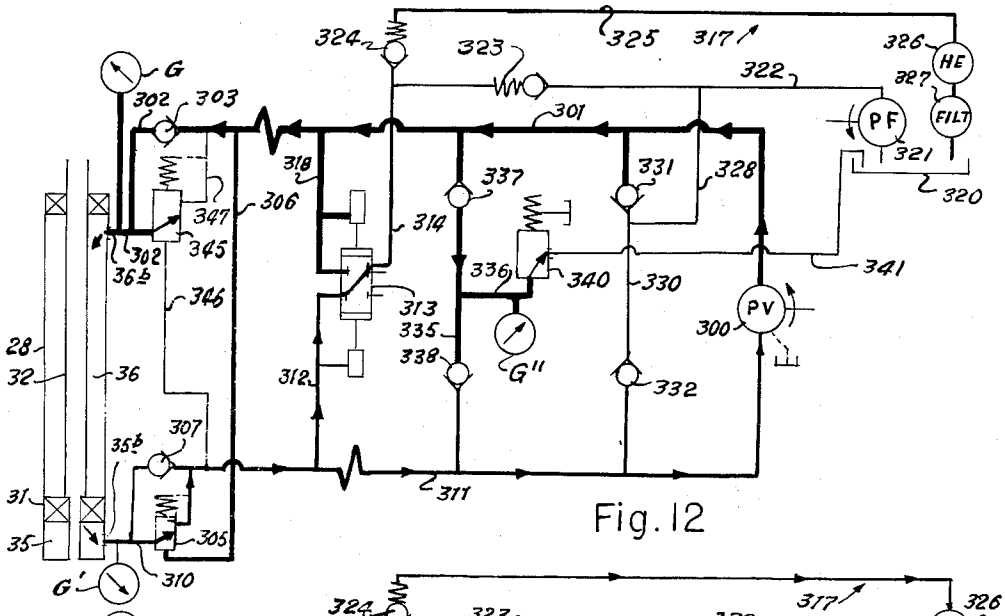


Fig. 12

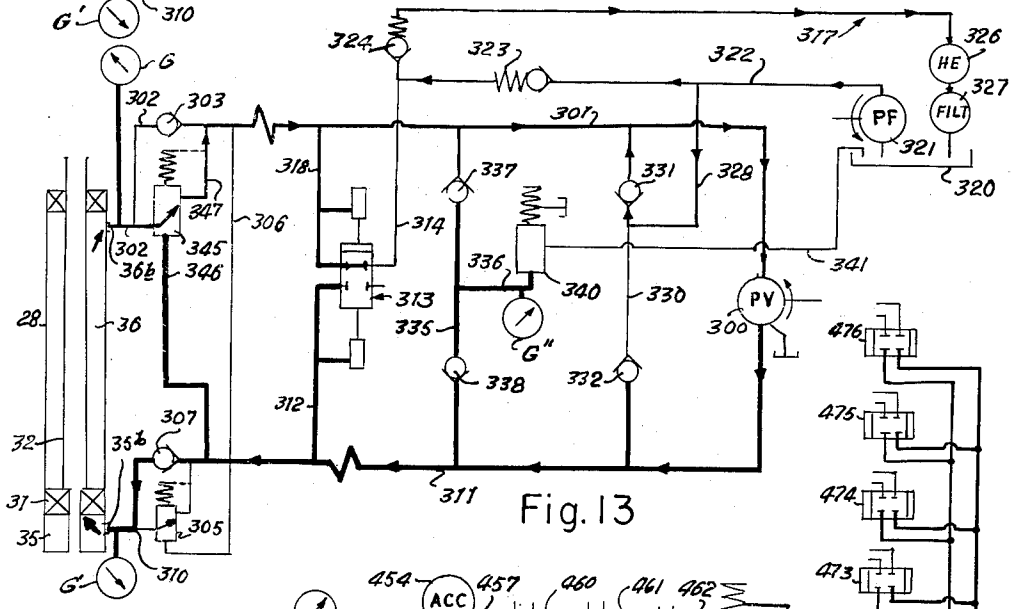


Fig. 13

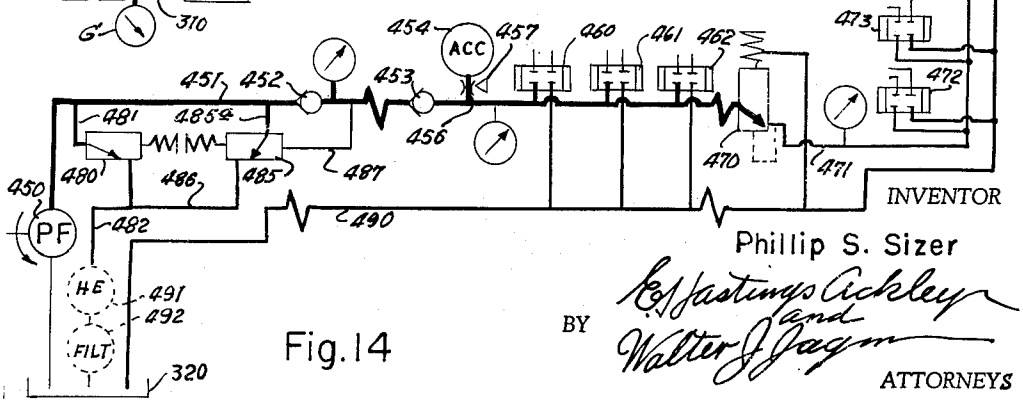


Fig. 14

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APPARATUS FOR MOVING A WELL FLOW CONDUCTOR INTO OR OUT OF A WELL

Filed April 17, 1961 5 Sheets-Sheet 5

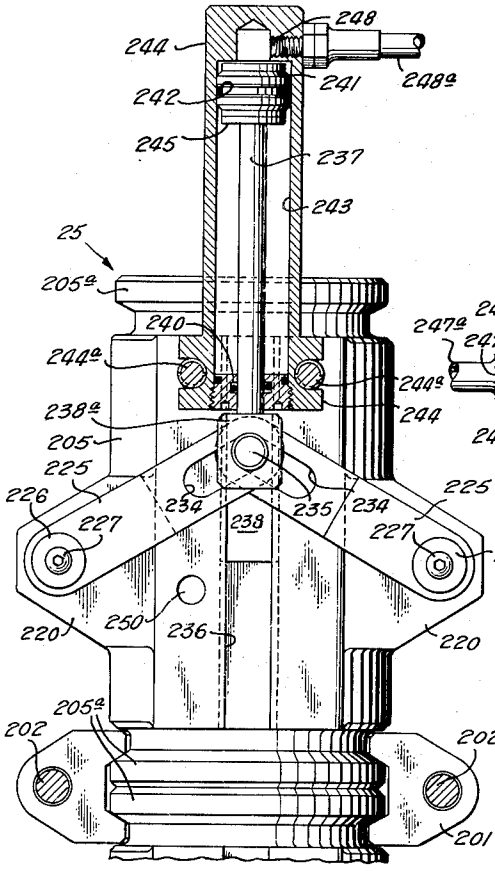


Fig. 15

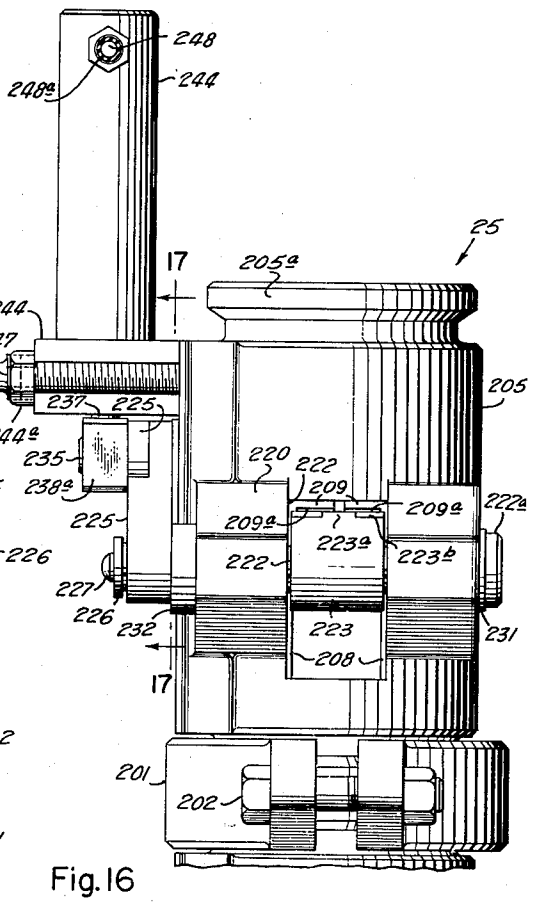


Fig. 16

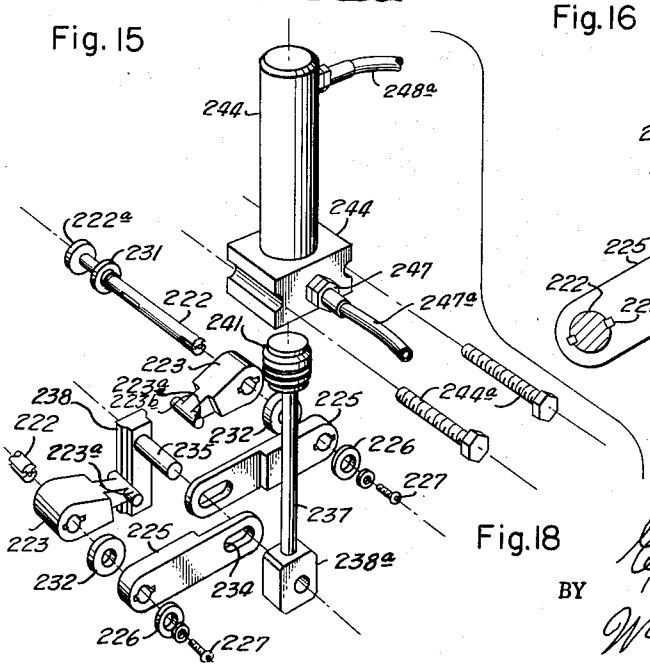


Fig. 18

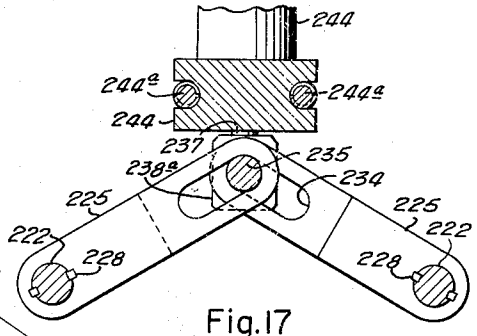


Fig. 17

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United States Patent Office 3,215,203 Patented Nov. 2, 1965

3,215,203

APPARATUS FOR MOVING A WELL FLOW CONDUCTOR INTO OR OUT OF A WELL

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Filed Apr. 17, 1961, Ser. No. 103,351
34 Claims. (Cl. 166—77)

This invention relates to well tools and more particularly to apparatus for moving a well flow conductor, such as a tubing string, into or out of a well.

One object of this invention is to provide a new and improved apparatus for moving a flow conductor into or out of a well.

An important object of the invention is to provide a new and improved apparatus for moving a flow conductor into or out of a well through a well head against well pressure which is mounted on and entirely supported by the well head, whereby said apparatus may be used on offshore, on water or marine wells having no derrick or working platform in connection with the well, thus providing means for running pipe or the like into or out of such wells without the use of a derrick or the necessity to build a platform to support hoisting equipment and the like.

A further object is to provide an apparatus of the character described for moving pipe into or out of a well wherein the apparatus is entirely supported by the well head and is operated by fluid pressure from a source independent and external of the well.

A particular object is to provide an apparatus of the character described comprising gripping means vertically reciprocable and selectively engageable with the flow conductor, or the like, to snub the same into or out of a well, wherein the gripping means for gripping the tubing and the means for imparting reciprocatory motion to one of said gripping means relative to the other are energized by fluid pressure means, and wherein the force applied to the gripping means to move the conductor is laterally balanced longitudinally of the apparatus and the conductor being moved thereby.

A still further object is to provide apparatus arranged to be mounted on and supported solely by a wellhead for controlling the movement of tubing in a well, which includes an assembly of hydraulically operated blowout preventers for preventing the escape of fluids between the tubing and the well casing and a plurality of hydraulically operated pipe gripping assemblies, each selectively operable to engage the tubing, and wherein hydraulic fluid pressure operated means is provided for moving one of the pipe gripping assemblies reciprocably longitudinally relative to the other to lower or raise the tubing in the well.

A still further object is to provide an apparatus for moving or snubbing a flow conductor, such as a tubing, into or out of a well against fluid pressure within the well having a tubing handling means for positioning a stand of tubing within the tubing moving apparatus or for removing the tubing therefrom, and wherein both the moving apparatus and the handling means are entirely mounted on and supported by the wellhead.

A still further object is to provide a slip type gripping assembly for use with snubbing apparatus wherein the slips are moved by hydraulic or fluid pressure between inoperative or non-gripping positions and operative tubing gripping position, and wherein said gripping slips may be held in such operative gripping position by mechanical locking means independently of the maintenance of the hydraulic or fluid pressure.

A still further object is to provide a new and improved hydraulically operated slip type pipe gripping assembly for use with well flow conductor snugging apparatus.

Another object is to provide a new and improved hydraulic system for controlling the action of the hydraulic fluid pressure operated piston and cylinder operating means for operating the movable gripping means of the snubbing apparatus.

Still another particular object is to provide a fluid pressure control system for controlling the movement of the snubbing piston in a snubbing apparatus of the character described wherein safety means is provided for automatically maintaining the pressure in the cylinder on opposite sides of the piston of the operating means for moving the traveling snubber to automatically lock the piston and the traveling snubber connected therewith against movement with the well pipe in the event of a pressure failure in the fluid pressure system.

Additional objects and advantages of the invention will be readily apparent from the reading of the following description of a device and system constructed and operating in accordance with the invention, and reference to the accompanying drawings thereof, wherein:

FIGURE 1A is a view in elevation of the lower portions of an apparatus embodying the invention and related equipment mounted on a wellhead of an off-shore well;

FIGURE 1B is a view similar to FIGURE 1A, being a continuation thereof, showing upper portions of the apparatus;

FIGURE 2 is a schematic vertical sectional view of the gripping and the sealing assemblies of the apparatus of FIGURE 1A, showing the arrangement of the same when forcing tubing into the well against well pressure;

FIGURE 3 is a view similar to FIGURE 2 showing the arrangement of the gripping and sealing assemblies while holding the tubing against well pressures as the traveling snubber or gripping member is being moved upwardly to take another grip on the tubing;

FIGURE 4 is a view similar to FIGURE 2 showing the arrangement of the gripping and sealing assemblies during lowering of the tubing into the well when the weight of the tubing exceeds well pressure;

FIGURE 5 is a view similar to FIGURE 4 showing the tubing supported momentarily by the stationary snubber or gripping member while the traveling snubber of the gripping assembly is being moved upwardly to position to again support and lower the tubing;

FIGURE 6 is a schematic view of the apparatus and a hydraulic system for operating and controlling the same;

FIGURE 7A is a schematic sectional view of a four-way valve for controlling a vertically movable piston of the apparatus showing the valve in position to cause the piston to move downwardly;

FIGURE 7B is a view similar to FIGURE 7A showing the valve positioned to cause upward movement of the piston;

FIGURE 7C is a view similar to FIGURE 7A showing the valve moved to position to prevent actuation of the piston in either direction;

FIGURE 8 is a view, partly in elevation and partly in section, with some parts broken away, showing the two lower or stationary gripping slip assemblies comprising the stationary snubber of gripping member of the apparatus;

FIGURE 9 is a cross-sectional view taken along the line 9—9 of FIGURE 8;

FIGURE 10 is a fragmentary cross-sectional view similar to FIGURE 9 but showing the slips in retracted position;

FIGURE 11 is a top view of the slips and inserts of the upper assembly illustrated in FIGURE 8;

FIGURE 12 is a schematic view of a modified form of hydraulic system for operating and controlling the

movement of the snubbing apparatus embodying the invention, illustrating the operation of the system for moving the snubbing piston downwardly;

FIGURE 13 is a similar schematic view of the hydraulic system of FIGURE 12, illustrating the operation of the system for moving the snubbing piston upwardly;

FIGURE 14 is a schematic view of a modified form of hydraulic system for controlling the operation of the slip assemblies and the blowout preventer system;

FIGURE 15 is an enlarged view of one of the snubbers of the gripping assemblies showing portions thereof in section;

FIGURE 16 is a view of the snubber of FIGURE 15 taken to one side at right angles to FIGURE 15;

FIGURE 17 is a fragmentary sectional view of the snubber operating linkage and piston connections taken on the line 17—17 of FIGURE 16; and

FIGURE 18 is an exploded view of the hydraulic operating cylinder and piston assembly and lever mechanism for operating the snubber of FIGURE 16.

Referring to FIGURES 1A and 1B of the drawings, one apparatus embodying the invention is shown in use with a well **10**, located in a body of water **11**. The well has the usual well casing **13** which extends above a protective caisson **14** and is connected at its upper end to the Christmas tree control assembly or to the wellhead **15**, and is protected against collision with floating debris or surface craft by a cribbing **12**, constructed of piling and timbers.

The apparatus embodying the invention is adapted for use on such marine or offshore wells having no derricks or platforms for supporting hoisting equipment and the like, and hence is designed to be mounted on the wellhead and entirely supported thereby. The apparatus includes a master valve **16** which is secured to the upper end of the wellhead with the axial bore of the valve in axial alignment with the bore of the casing. The valve is provided for the purpose of shutting or closing off the upper end of the bore of the casing when no tubing extends through the valve. Annular laterally-directed flanges **16***a* and **16***b* on the lower and upper faces of the valve housing have bolts, or other suitable fastening means, extending through suitable apertures of the flanges to secure the valve body to the wellhead and to elements of the apparatus located above the valve.

Mounted above the valve **16** in vertical upward succession are a spool **17**, a safety blowout preventer **18**, a lower operating blowout preventer **19**, a spool **20**, and an upper operating blowout preventer **21**. Each of these elements is provided with external annular flanges at its upper and lower ends for connecting it to elements above and below the same. The blowout preventers are of a conventional type which are operated by fluid pressure and each has a vertical flow passage axially aligned with the bore of the casing. The preventers, which are used to retain pressure within the casing when a length of tubing is being passed therethrough, may be actuated to close off the annular space around the tubing to prevent the well from "blowing out," i.e., the fluid pressure escaping from the well, even though the vertical passage above the preventers is open to the atmosphere. It is to be understood, of course, that the tubing is plugged to prevent the well from blowing out therethrough. When in their operational tubing engaging position, the preventers do not preclude longitudinal movement of the tubing although manipulation of the preventers is required to move the tubing couplings therepast.

Above the uppermost blowout preventer **21** are mounted in vertical upward succession a stripper **22**, a spacer spool **23**, and slip assemblies **24** and **25** comprising a lower stationary snubber means **26**, each of which is provided at its ends with annular flanges for facilitating connection thereof to elements above and below and with a flow passage axially alignable with the bore of the well casing. The stripper which is connected to the blowout preventer **21** has essentially a highly resilient annular packoff and acts as a seal member for low pressures and as a wiper means for the tubing as it moves upwardly therethrough. Because of its resilience, it has the particular advantage of allowing passage of tubing couplings without requiring its manipulation. The slip assemblies **24** and **25**, which are installed above the spool **23** and inverted with respect to one another, constitute the lower or stationary snubber means used to engage the well tubing to prevent its longitudinal movement therepast. One of the slip assemblies is adapted to prevent the tubing from being blown or expelled upwardly from the well by fluid pressure within the well, while the other assembly is adapted to support the tubing to prevent it from falling into the well due to gravity. When a particular slip assembly is functionally employed, of course, is determined by the relation of the well pressure to the total weight of tubing.

A pistol and cylinder assembly or travelling snubber operating means **27**, mounted above the slip assembly **25**, carries an upper or travelling snubber **40** and with it controls the raising and lowering of tubing into or from the well casing through the wellhead. The operating means assembly includes an outer cylinder **28**, provided with annular flanges at its ends for connecting it to elements above and below the cylinder, and an inner cylinder **29** mounted concentrically in the outer cylinder and of equal length therewith. The cylinder assembly is mounted on a spool **30** interposed between said assembly and the slip assembly or stationary snubber **26**. An annular piston **31**, shown in FIGURES 2 through 5, is slidably mounted in the annular cylinder formed between the concentric outer and inner cylinders and is secured to the lower end of a tubular piston rod **32** which extends upwardly from the piston between the inner and outer cylinders and upwardly beyond the upper ends thereof. A suitable seal **33**, such as a packing gland or the like, is attached to the upper end of the inner wall of the outer cylinder **28** to provide a fluid-tight seal between the tubular piston rod and the outer cylinder. The annular space between the cylinders **28** and **29** is closed at their lower ends by a transverse annular end member **33***a* which defines, with the cylinders and the piston **31**, a lower fluid-tight chamber **35**. Since the outer cylinder **28**, the piston rod **32**, the seal **33** and piston **31** define an upper fluid-tight annular chamber **36** above the piston, it is apparent that the piston can be readily moved upwardly by introducing fluid under pressure from a suitable supply of fluid into the lower annular chamber **35** below the piston, or that it can be moved downwardly by applying fluid pressure in the upper chamber **36** above the piston, provided, of course, that fluid is permitted to escape from the chamber on the side of the piston opposite that to which the pressure is being applied.

A third slip assembly, identical in construction to each of the slip assemblies **24** and **25**, comprises the upper or travelling snubber **40** and is secured to the upper end of the tubular piston rod **32**, so as to be raised and lowered by longitudinal movements of the piston rod. When the slip assembly of the snubber **40** is inverted with its slips oriented as illustrated in FIGURES 2 and 3, the slips may be actuated to grip a length of tubing which extends coaxially through the concentric cylinders, and by controlled application of hydraulic pressures in the chambers on either side of the piston to move the piston downwardly, will force the tubing into the well against the force of well pressure. The lower stationary snubber or slip assembly **26** is employed to hold the tubing during the upstroke of the piston, the travelling snubber assembly **40** being disengaged from the tubing and moved upwardly with the piston and piston rod relative to the tubing.

To limit deflection of the tubing under large compressive loads a tubular guide **255***a* may also be provided to increase the range of well pressures over which the apparatus is operable. The guide, of course, should be mounted co-axially with the inner cylinder **29** in any suitable manner.

When the weight of tubing is sufficient to overcome the force of well pressure, the upper slip assembly or travelling snubber **40** is oriented as illustrated in FIGURES 4 and 5. In this position the slip assembly supports the tubing as it is lowered by downward movement of the piston effected by suitable application of fluid pressures on either side of the piston of the snubber operating means. In this particular relationship of well pressure and tubing weight, the slip assembly **24** of the lower stationary snubber is employed to hold the tubing against downward movement while the travelling snubber **40** is moved upwardly relative to the tubing to engage the tubing at a higher point thereon.

Thus, it will be seen that the slip assembly of the travelling snubber **40** is used cooperatively with either the slip assembly **24** or **25** of the stationary snubber, depending on the relationship of tubing weight and well pressure. Of course, occasionally it may be desired to engage the tubing with all of the slip assemblies simultaneously to prevent longitudinal movement of the tubing in either direction, especially as when the above mentioned conditions may be expected to vary suddenly and without notice.

The mechanism for lifting and lowering the lengths of tubing which are lowered into and lifted out of the cylinder assembly is also itself supported by the wellhead and the equipment thereabove and comprises a mast or gin pole **41** held in vertical position by clamps **42** and **43** attached to the stripper **22** and the spool **30**, respectively. The gin pole is provided with a reel **44** and pulley **45** attached thereto by laterally extending brackets **46** and **47**, respectively. A cable **48**, spooled on the reel and reeved about the pulley is equipped with a hook **49** at its free end for the attachment of bails (not shown), or the like, for engaging single lengths of tubing, whereby the tubing lengths may be easily lifted or lowered by operation of the cable reel.

For the purpose of supporting personnel and control equipment, such as a value control panel, or the like, a horizontal platform **51** is disposed adjacent the upper end of the piston and cylinder assembly **27** and fastened to the wellhead supported equipment by a plurality of braces **52**. The braces are arranged with their lower ends spaced circumferentially around the piston and cylinder assembly **27** and secured to the spool **30** in any suitable manner, as by welding, and with their upper ends supporting and secured to the platform by any suitable means. Apertures **51***a* and **51***b* are provided in the platform for accommodating the piston and cylinder assembly and gin pole which extend therethrough. The platform has a railing **53** supported by stanchions **54**. The cable reel on the gin pole is located at a convenient height above the platform so as to be easily operated by a person standing on the platform.

Racks may be provided on some auxiliary structure, such as a barge or the like, which is preferably independent of the well or its cribbing, for holding the tubing which is to be inserted in or removed from the well. In addition, the rack supporting structure may also contain the hydraulic pump and its prime mover or power plant for supplying fluid pressure to the piston and cylinder assembly. The connections between the pressure supply and the piston and cylinder assembly **27** must be sufficiently flexible and of ample length to accommodate any movements between the immovable wellhead and the auxiliary structure.

When it is desired to force or snub tubing into the well, the apparatus is arranged as illustrated in FIGURES 2 and 3. The master gate valve **16** is moved to the open position illustrated in FIGURE 2 and the tubing string T, which comprises a plurality of lengths of tubing, fastened together by a coupling C, extends through the master gate valve and the wellhead **15** into the well casing. The blowout preventer **21** is first moved to closed position to seal around the tubing and prevent the well from blowing out while the blowout preventers **19** and **18** are initially open. The upper travelling snubber **40** is moved into gripping engagement with the tubing and the slip assemblies **24** and **25** of the stationary snubber are moved to open position wherein they are disengaged from the tubing to permit the same to be moved downwardly therethrough. Fluid under pressure is introduced into the chamber **36** through a port **36***b* to cause the piston **31** to move downwardly as fluid is permitted to escape through the port **35***b* from the chamber **35** below the piston. The travelling snubber being connected to the piston by the tubular piston rod **32**, downward movement of the piston and tubular piston rod now causes the tubing string to move downwardly into the well against the pressure therein.

In order to provide positive control of the pipe movement, the escape rate of fluid from the lower chamber **35** through the port **35***b* is controlled to apply a back pressure in the lower chamber acting upwardly against the piston. Such control also provides for prompt cessation of downward movement of the tubing to preclude the possibility of equipment damage should the lower end of the tubing encounter resistance in the casing, such as a sand bridge or a point of decreased internal diameter of the casing. By bleeding fluid from beneath the piston and at the same time keeping the chamber **36** above the piston filled with fluid to exclude air, a sufficient back pressure is maintained to permit the tubing to move slowly into the well.

When the coupling C has been moved downwardly to a point just above the upper operating blowout preventer **21**, the lower operating blowout preventer **19** is closed and the upper blowout preventer **21** is opened to permit downward movement of the coupling therepast to the position shown in FIGURE 3, whereupon the upper blowout preventer **21** is again closed and the lower operating blowout preventer **19** opened to permit the coupling to pass on into the well. At the end of the piston's downstroke, the slip assembly **25** of the stationary snubber is actuated to grip the tubing and the slip assembly of the upper travelling snubber **40** is subsequently disengaged from gripping engagement with the tubing, as is illustrated in FIGURE 3. The slip assembly **25** of the stationary snubber thus serves to hold the tubing against upward movement from the well while the piston of the operating means **27** is being returned to its uppermost position. At the end of the piston upstroke, the slip assembly of the travelling snubber **40** is actuated to gripping engagement with the tubing, and the slip assembly **25** of the stationary snubber **26** disengaged therefrom, so that the operating means **27** may once again be operated to cause the piston **31** to be forced downwardly to move the tubing further downwardly into the well against the force exerted by well pressure. An additional length of tubing is coupled to the string after a length of the tubing has been forced into the well. By repeating the foregoing sequence of operations, any desired length of tubing may be readily run into the well until the weight of the tubing alone causes it to tend to move downwardly in the well, i.e., until the tubing weight becomes so great that the well pressure acting upon the cross-sectional area of such tubing is no longer sufficient to expel or blowout the tubing string from the well.

When the tubing becomes sufficiently heavy to move downwardly by its own weight, overcoming not only well pressure but also the friction of sealing elements of the blowout preventer, the slip assembly of the traveling snubber **40** is removed, inverted, and reinstalled in the position illustrated in FIGURE 4, with slips wedging downwardly and inwardly. The tubing T is then supported against falling or downward movement by the gripping engagement of the slips of the assembly with the tubing, whereby such tubing may be lowered into the well through the closed upper operating blowout preventer **21**. Just before the end of the down-stroke of the

the operating means 27 is reached, the slip assembly 24 of the stationary snubber is engaged with the tubing and the weight of the tubing string is thus transferred to the lower stationary snubber, whereupon the slip assembly of the upper traveling snubber is disengaged from the tubing as illustrated in FIGURE 5. The piston and tubular piston rod 32 are then moved upwardly while the stationary snubber 26 supports the tubing string and, just before the upper end of the stroke is reached, the slip assembly of the traveling snubber is moved to gripping engagement with the tubing string and said tubing string is lifted to permit the ready disengagement of slip assembly 24 of the stationary snubber therefrom. This sequence of operation can then be repeated to lower the tubing further into the well, the couplings connecting succeeding lengths of tubing being passed through the operating blowout preventers in the manner previously described, by closing the lower preventer, opening the upper preventer, moving the coupling past said upper preventer, reclosing the upper and opening the lower preventer. The lowermost or safety blowout preventer 18 is used for sealing off around the tubing in case of emergencies such as failure of either of the operating preventers or to permit replacement of the seal elements of such operating preventers.

By reversing the procedure described above, the apparatus can be used to remove the tubing from the well. During such removal, while the weight of the tubing string is sufficient to unbalance the well pressure acting on the cross sectional area of the tubing, the tubing string is lifted by the traveling snubber 40 with the slip assembly in the position shown in FIGURES 4 and 5, and by introducing hydraulic fluid under pressure into the chamber 35 below the piston 31 of the snubber operating means 27 while releasing fluid pressure from the upper chamber 36. When removing tubing while the well pressure is sufficient to expel it from the well, the rate of upward movement is positively controlled by slowly releasing or bleeding the fluid from the upper chamber 36 above the piston. The tubing, of course, can move only as fast as the releasing or bleeding of fluid is permitted to take place. The annular chamber 37 between the tubular piston rod and the inner cylinder 29 is vented at its upper end, to permit fluid to escape or enter by the loose fit provided between the piston rod and the annular guide bushing 38 mounted on the upper end of said inner cylinder.

One form of hydraulic system which may be used to actuate the piston 31 is illustrated schematically with the snubbing and sealing apparatus in FIGURE 6. The entire liquid circuit represented in the system is filled with a substantially incompressible fluid, such as common hydraulic fluid, and a supply of the fluid is contained in the reservoir or tank 101. A constant delivery pump 102, which may be of any suitable type readily available on the market and powered by a suitable motor, picks up fluid from the reservoir through the conduit 103 and discharges the fluid through the conduit 104 at a greatly increased pressure. The fluid under pressure from the pump 102 is delivered through a check valve 105 and a conduit 106 to a 4-way valve 109 for controlling the admission of the fluid to the chambers on either side of the piston.

Connecting with the conduit 106 through a conduit 107*a* is an accumulator 107 for storing a volume of fluid under pressure. Should the pump or its prime mover fail, the capacity of the accumulator is sufficient to actuate at least several of the slip assemblies and blowout preventers so that the tubing may be held against movement relative to the wellhead and escape of fluid pressure from the well may be prevented until the pump or prime mover is again rendered operative. In addition, a pressure relief valve 108 is connected in fluid communication with the conduit 106 and the reservoir through the conduits 108*a* and 108*b*, respectively. The pressure relief valve is set to open at a predetermined pressure, which occurs after the accumulator has been charged and there is no demand for power fluid, to discharge fluid from the pump into the reservoir and prevent excessive pressures in the system while permitting continuous operation of the pump.

The manner in which the 4-way valve 109 controls the application of fluid pressure to the piston and cylinder assembly of the operating means 26 is illustrated in FIGURES 7A, 7B, and 7C.

When the valve is in the position shown in FIGURE 7A, the piston is moved upwardly. Fluid under pressure enters from the conduit 106 and passes through the passageway 110 into the conduit 111 which conducts the pressure fluid through the port 35*b* into the chamber 35 below the piston. As the piston is moved upwardly by the increased pressure in the lower chamber, fluid in the upper chamber 36 above the piston is expelled and returned to the reservoir 101 through the port 36*b*, conduit 112 and passageway 113 of the valve into the conduit 114 which connects with the reservoir through the communicating conduits 115 and 116.

When in the position shown in FIGURE 7B, fluid under pressure from the conduit 106 is delivered through the valve passage 113 into the conduit 112 which conducts the fluid through the port 36*b* into the chamber 36 above the piston. As the piston is moved downwardly by the increased pressure in the chamber above the piston, fluid in the chamber below the piston is released or expelled through the opening 35*b*, conduit 111, valve passage 110, communicating conduits 114, 115 and 116, into the reservoir 101.

When the valve is positioned as shown in FIGURE 7C, no flow can take place through the valve since all its passages are closed. In this position of the valve, the substantially incompressible hydraulic fluid is trapped in both of the chambers on opposite sides of the piston and the piston can neither move up nor down, but remains locked in whatever position it may be when the valve is closed.

Pressure fluid from the conduit 106 is also delivered at a reduced pressure to 4-way valves 124, 125, and 126, which control the operation of the slip assembly of the traveling snubber 40, and the slip assemblies 25 and 24 of the stationary snubber, respectively, and to 4-way valves 127, 128, and 129 which control the operation of the blow-out preventers 21, 19 and 18, respectively. The fluid under pressure in the conduit 106 is delivered by means of a conduit 120 to and through an adjustable reducing valve 121 to be discharged at a predetermined reduced pressure to the conduit 122 and thence to a distributing conduit 123 which conducts the fluid to the slip assembly and blowout preventer control valves. These control valves are substantially the same as the 4-way valve 109 but operated by movement to only two control positions, similar to the valve positions shown in FIGURES 7A and 7B, which determine whether the particular slip assembly or blow-out preventer controlled thereby is in operative tube engaging position or in inoperative position.

When the valve 127 is in one of its two positions fluid under pressure is conducted to the upper operating blowout preventer 21 through the conduit 130 to actuate the hydraulically operated sealing elements of such blowout preventer to tubing engaging position, as illustrated in FIGURE 3. Fluid expelled from the hydraulic cylinder associated with the preventer is returned to the reservoir through the conduit 131, the valve 127 and conduits 115 and 116. When the valve is moved to the other of its positions, the conduit 131 is supplied with fluid under pressure from the distribution line 123, and the conduit 130 is connected to the conduit 115 through the valve, thus reversing the hydraulic action of the blowout preventer to cause the seal elements to be disengaged from the tubing.

In similar manner, the valves 128 and 129 many be manipulated to control the lower operating blowout preventer 19 and the safety blowout preventer 18, respectively; and, the valves 124, 125 and 126 may likewise be employed to control the operation of the slip assemblies.

Controls which are presently available on the market could be installed in the conduits **111**, **112**, and **114** to control the action of the piston more closely as to force and speed. For instance, such controls could cause the piston to move the tubing into or out of the well with only slight force but to cause it to move fairly rapidly on the return stroke. This would, in most cases, be desirable since the piston would readily stop should the lower end of the tubing encounter an obstruction in the well bore, thereby preventing damage to the tubing and equipment. It would also be desirable to spring load the valve **109** so that it would always be in the closed or fluid blocking position shown in FIGURE 7C unless manually held out of that position. The provision of such a biasing means would insure that the tubing would be moved only as intended by the operator.

A modified form of hydraulic system for controlling the reciprocal movements of the piston **31** of the traveling snubber operating means **27** is illustrated in FIGURES 12 and 13 and represents a preferred hydraulic control system to be employed witht the snubbing apparatus described therein.

The system, which is filled throughout with hydraulic fluid, includes a reversible hydraulic pump **300**, which may be of the cross center servo control of swash plate type, for producing hydraulic pressure of a desired high value throughout the system. The pump, which produces fluid pressure of the order of two thousand (2000 lbs. per sq. in.) pounds per square inch, and constitutes the principal power source of the system, is adapted to be operated by a servo control mechanism so that the direction of output of fluid from the pump can be readily reversed.

In the operation of the system for moving the snubber operating means piston downwardly, and which is schematically illustrated in FIGURE 12, fluid under pressure from pump **300** is delivered through the conduits **301** and **302** to the port **36***b* of the outer cylinder **28**, thereby introducing fluid pressure into the chamber above the piston and tending to move the piston downwardly. A by-pass check valve **303** in the conduit **301** prevents reverse flow of fluid in the conduit.

A direct operating remotely controlled counterbalance valve **305**, which is spring loaded to normally closed position, is connected on its inlet side by a conduit **310** to the lower cylinder port **35***b* and on its outlet side by a conduit **311** with the low pressure side of the pump **300**. A by-pass check valve **307** is connected between the conduits **310** and **311** to prevent back flow from the conduit **310** to the conduit **311**. The counterbalance valve is opened by fluid pressure conducted thereto from the conduit **301** by the branch conduit **306** connecting the two. The valve is designed to open in response to fluid pressures applied thereto from the conduit **306** in excess of a predetermined value, normally 200 to 250 lbs. per sq. in. and, when so opened, permits fluid to be released or drain from the chamber **35** beneath the piston through the cylinder port **35***b* and conduits **310** and **311** to return to the low pressure side of the pump **300**. The piston **31** may thus move downwardly in the cylinder **28** of the traveling snubber operating means **27**.

Since the annular cross-sectional area of the lower chamber **35** below the piston **31** is greater than the annular cross-sectional area of the upper chamber **36** thereabove, downward movement of the piston and the piston rod connected therewith expels or ejects more fluid from the lower chamber than can be admitted to the upper chamber above the piston. Hence, an excess flow line **312** is provided to conduct the excess of fluid from the return line **311** through a separate path to a fluid reservoir or tank **320**. The excess flow line **312** is connected at one end with the return flow line **311** and conducts excess flow therefrom to a fluid pressure pilot operated four-way spool valve **313**, thence through a conductor **314** into a cooling circuit **317** which communicates with the reservoir **320**. A branch conduit **318** also connects the supply feed conduit **301** with the pilot operated four-way spool valve **313** for effecting control of the operation thereof and for other purposes to be hereinafter explained. The pressures from the two lines **312** and **318** are directed to and act upon opposing hydraulic operators or diaphragms, or the like, to move the valve in accordance with the imbalance of the pressures in the two lines. Thus, the valve **313** always provides for direct communication between the conductor **314** and the excess flow line **312** or the branch conduit **318**, whichever of the latter two contains the lower pressure. When the pressure in the feed line **301** and branch line **318** is high relative to the pressure in the line **312**, the valve **313** is moved to the position shown in FIGURE 12, which permits the excess fluid forced out of the lower chamber **35** to pass through such valve and through the conductor **314** into the cooling circuit **317** and thence to the reservoir **320**. Conversely, during the upstroke of the piston **31** (shown in FIGURE 13), the pressure in the excess flow line **312** is greater than that in the branch conduit **318** and these pressures acting on the valve **313** shift the valve automatically to connect the branch conduit **318** with the conductor **314**, as shown in FIGURE 13. In this position of the valve, fluid may flow from the cooling circuit **317** into the branch conduit **318**, and thence through the conduit **301** to the pump **300**, where such additional fluid from the cooling circuit makes up the shortage of fluid in the operating circuit resulting from the larger volume of fluid introduced into the lower chamber **35** as compared with the smaller volume of fluid displaced from the upper chamber **36** by upward movement of the piston **31**.

The cooling and circulating circuit **317** comprises the reservoir **320**, a circulating pump **321** which picks up fluid from the reservoir and circulates it from the outlet side through a conduit **322** and a check valve **323** to the point of connection with the conduit **314**, and thence through a check valve **324** and a conduit **325** to a heat exchanger **326**, which cools or controls the temperature of the hydraulic fluid being circulated and maintained in the reservoir **320**, and thence through a filter **327** back to the reservoir. The check valves **323** and **324** are each spring loaded and maintain predetermined back pressures upstream thereof in the conduits **322** and **314**. The check valve **323** is preferably set to maintain a pressure differential of approximately 90 lbs. per sq. in. thereacross, while the check valve **324** is preferably set to maintain a differential of approximately 60 lbs. per sq. in. across it, so that the fluid pressure in the conduit **322** between the pump **321** and the check valve **323** will be approximately 150 lbs. per sq. in., while the pressure between the check valves **323** and **324** and in the conductor **314** will be approximately 60 lbs. per sq. in.

A branch conduit **328** conducts fluid from the conduit **322** to a cross-connecting conduit **330** which connects the feed line or conduit **301** with the return conduit **311**. Opposed check valves **331** and **332** are disposed in the conduit **330** on opposite sides of the connection of the branch conduit **328** therewith, so that fluids from said branch conduit can be directed in either direction to either of the conduits **301** or **311**, but so that fluid from those conduits cannot flow back through the conduit **328** to the cooling and circulating system **317**. This arrangement provides additional means for supplying hydraulic fluid to the operating circuit in the event the volume thereof is diminished for any reason and is particularly used in the operation of the circuit for moving the piston **31** of the traveling snubber operating means upwardly, as will be hereinafter more fully described.

A second cross feeding conduit **335** connects the feed line or conduit **301** with the return line or conduit **311**, and a relief conduit **336** is connected at one end with said cross feeding conduit between a pair of opposed check valves **337** and **338**, whereby hydraulic fluid from either of the conduits **301** and **311** may pass said check valves

to the relief conduit 336 but cannot flow back from the relief conduit to the conduits 301 and 311. The relief conduit connects at its other end with an adjustable resiliently loaded relief valve 340 whereby fluid under pressure in the relief line 336 may open said relief valve in the event pressure in the relief line or the conduits communicating therewith exceeds a predetermined value, to permit the hydraulic fluid to pass through the valve and an exhaust or dump conduit 341 to the reservoir 320. This prevents overloading and rupturing any of the lines or valves of the system. If desired, the dump conduit 341 could be connected to the branch conduit 328 so as to deliver the fluid from the relief valve 340 to the cooling and circulating circuit 317, where the fluid would pass through the heat exchanger 326 and may thus be cooled and filtered to prevent overheating.

Pressure gauges G, G' and G'' may be connected in the system at various points to indicate the operating pressures therein at such points, as clearly shown in the drawings.

Operation of the system for causing the operating means 27 to move the traveling snubber upwardly is schematically illustrated in FIGURE 13. For this purpose, the direction of flow of fluid under pressure from the pump 300 is reversed, by operation of the servo mechanism controlling the vane of the pump in the usual manner, so that the pressure from the pump is delivered in the opposite direction, as shown by the arrow, to deliver high pressure through the conduit 311 past the check valve 307 and through the conduit 310 to the cylinder port 35*b* in the lower portion of the cylinder 28, whereby fluid under pressure is introduced into the chamber 35 below the piston 31 and forces the piston upwardly.

A direct operating remotely controlled counterbalance valve 345 is connected on one side to the conduit 302 and on its other side by an exhaust conduit 347 to the conduit 301 beyond the check valve 303, and has an operating conduit 346 connected therewith for conducting pressure from the conduit line 311 to the valve to operate the same. When the pressure in the line 311 and conduit 346 attains a predetermined value, substantially the same as that which opens the valve 305, and thus of the order of 220 to 250 lbs. per square inch, the valve 345 is moved to an open position to permit the fluid from the upper chamber 36 to pass outwardly through the upper port 36*b* to the conduit 302 and through the valve 345 and the conduit 347 to the conduit 301, and thence to the pump 300. Check valve 303 directs all fluid exhausted from the chamber 36 through the valve 345. Fluid in the line 301 returned to the pump is again placed under pressure and is directed into the conduit 311.

As the piston 31 is moved upwardly in the cylinder 28 of the operating means, it will be apparent that a greater amount of fluid must be introduced into the chamber 35 below the piston than is expelled or exhausted from the chamber 36 thereabove, due to the difference in cross-sectional area of the two chambers. Hence, supplemental fluid is delivered into the conduit 301 from the cooling and circulating system 317 for delivery to the low pressure side of the pump 300. The branch conduit 328 leading from the conduit 322 will conduct fluid from the cooling circuit to the conduit 330 between the check valves 331 and 332. Since the higher pressure from the conduit 311 is applied to the check valve 332, the lower pressure fluid introduced into the conduit 330 will pass through the check valve 331 and into the conduit 301 for supplementing the volume of hydraulic fluid delivered to the pump 300. Pressure in the cooling and circulating circuit 317 is maintained at a value in excess of the pressure which is to be found in the conduit 301, so that hydraulic fluid will always be supplied from the circulating circuit through the conduits 328 and 330 to the conduit 301 when required. Supplemental fluid may also move from the cooling circuit 317 into the conduit 301 by way of the conductor 314, the spool valve 313 and the branch conduit 318 in cases where the demand is sufficiently great and the valve 313 is opened by the low pressure in the conduit 318 as compared with the pressure in the line 312 as has been explained.

Other elements in the hydraulic control system operate in the same manner as previously described. However, the valve 305 will remain closed, since the pressure in the conduit 306 is not adequate to open the same, and all hydraulic fluid in the line 311 will be directed through the check valve 307 and the conduit 310 into the chamber 35.

It will thus be seen that the hydraulic system disclosed in FIGURES 12 and 13 provides a sensitive control means for accurately and positively controlling movement of the snubbing piston.

In the event of a break or pressure failure in the system between the counterbalance valves 305 and 345 and the pump, the pressure in the conduits 306 and 346 will fall below that required to open the counterbalance valves 305 and 345 and thus those valves would remain closed to prevent flow of hydraulic fluid therethrough outwardly from the chambers 35 and 36. Simultaneously, the check valves 303 and 307 will prevent out-flow of fluids from either of the chambers 36 or 35 to the conduits 301 or 311, and the hydraulic fluid would thus be trapped in the two chambers and prevent any movement of the piston 31 therein. It will therefore be seen that this modified system provides a safety feature for automatically hydraulically locking the piston against movement in the event of failure or reduction of hydraulic fluid pressure or breakage of the hydraulic fluid conduits of the system, or failure of any of the valves in the system other than the counterbalance valves and the check valves 303 and 307.

It is important to note that the reversible hydraulic pump 300 has a constant load pressure of approximately 150 lbs. per sq. in, applied to its inlet side at all times, such fluid pressure being applied from the cooling and circulating circuit 317 by way of the branch conduit 328 and the cross connecting conduit 330. When the circuit is operating in the manner shown in FIGURE 12, the fluid pressure from the circulating circuit passes through the branch conduit 328 to the cross connecting conduit 330 and thence past the check valve 332 to the return conduit 311 where it acts on the inlet side of the pump. When the pump is operating in the manner shown in FIGURE 13, the pressure fluid from the circulating circuit is delivered from the branch conduit 328 to the cross connecting conduit 330 and flows thence through the check valve 331 to the conduit 301 for supplying the elevated pressure load to the inlet side of the pump 300. This arrangement prevents entry of air into the system and aids in supplying a sufficient volume of pressure fluid from the pump into the operating circuit, and is an important feature of the system.

It will be noted also that the network of conduits forming the hydraulic system provides means whereby any sudden surge of fluid pressure in any part of the circuit may be relieved by several different paths to protect the system against breaks resulting from the high pressure. For example, while the system is being operated in the manner illustrated in FIGURE 12, should a high pressure surge occur in the conduit 311 for any reason, as might occur if the conduit became plugged near the pump 300, the surge due to the momentum of the hydraulic fluid could be relieved by sending the fluid to the reservoir 320 through the excess flow line 312, the valve 313, the conductor 314 and the cooling circuit 317; or, the fluid could be directed through the conduit 335, the conduit 336, the relief valve 340 and the exhaust conduit 341 to the reservoir.

On the other hand, should a large demand be suddenly placed upon the circuit for any reason, there could be a tendency to cause a vacuum or to draw air into the system, creating a dangerous and unsatisfactory condition. If such a large demand did occur in the conduit 311, fluid could enter such conduit not only from the

pump **300** in the usual manner, but could enter it from the cooling circuit **317** through the conductor **314**, the valve **313** and the flow line **312** (since the low pressure in the conduit **311** would move the valve **313** to the position shown in FIGURE 12); but fluid also could enter the conduit **311** from the circuit **317** through the conduits **328** and **330**. These are important features of the hydraulic control system and provide for safety and efficiency of operation of the apparatus at all times.

In FIGURE 14 is illustrated a modified form of hydraulic system for controlling the operation of the snubber slip assemblies and the blowout preventers. The source of fluid for the system may be the same reservoir **320** as employed in the system illustrated in FIGURES 12 and 13 for controlling the snubbing piston, or may be a separate source. A constant volume pump **450** delivers fluid from the reservoir **320** through a supply conduit **451** to the manually operated four-way control valves **460**, **461**, and **462** which may be separately operated to control the operation of the slip assembly of the traveling snubber **40** and the slip assemblies **25** and **24**, respectively, of the stationary snubber. Check valves **452** and **453** in the supply conduit prevent the reverse flow of fluid therein.

An accumulator **454** stores a volume of fluid under pressure, which it receives from the supply line **451** through the conduit **456** and valve **457**, and fluid from the accumulator is adapted to operate the slip assemblies and blowout preventers should the pump fail or a conduit break occur.

A spring loaded pressure reducer **470**, set to operate to open at a pressure of approximately 300 lbs. per square in., is inserted in the line **451** to produce a lower downstream pressure for operating the blowout preventers **18**, **19**, and **21**. The reduced pressure is delivered from the reducer through the line **471** to the manually operated four-way valves **472** to **476**, respectively, for controlling operation of the blowout preventers and gate valves. The valves **472**, **473**, and **474**, for example, may be used to control the blowout preventers **18**, **19**, and **21**, respectively, and the valves **475** and **476** may constitute the controls for gate valves, such as the valve **16**.

A safety relief valve **480** is connected with the conduit **451** by a conduit **481** and with the reservoir **320** by a conduit **482** and permits bypassing hydraulic fluid from the conduit **451** back to the reservoir in the event of overloading of the system, and may operate to open, for example at pressures exceeding 1000 lbs. per sq. in.

An unloading valve **485**, of the same type as the unloading valves **305** and **345** of FIGURES 12 and 13, communicates with the supply conduit **451** through a branch conduit **485***a* and with the reservoir **320** through conduits **486** and **482**. A pilot conduit **487** connected into the supply conduit **451** beyond the check valve **452** transmits pressure from that portion of the conduit **451** beyond the check valve **453** back to the unloading valve **485**. This unloading valve may be set to operate at a pressure in the range of from 300 to 600 lbs. per sq. in. When the pressure in the accumulator **454**, and in the conduit **451** beyond the check valve **453**, equals or exceeds that for which the valve **485** has been set, the valve is in its fully open position and will permit unrestricted bypassing of the fluid therethrough and back to the reservoir, thus permitting the pump **450** to operate constantly by circulating the pressure fluid through the circuit formed by the supply conduit **451**, the branch conduit **485***a*, the valve **485**, the conduits **486** and **482**, and a heat exchanger **491** and filter **492** to the reservoir. When the valves **460**, **461** and **462** are actuated to operate their respective slip assembly **40**, **25** or **24**, the pressure in the supply conduit **451** may fall below the value for which the valve **485** has been set, whereupon said valve automatically closes, causing fluid pressure from the pump **450** to pass through the check valves **452** and **453** to the valves controlling actuation of the slip assemblies until the demand for fluid pressure is satisfied and until the circuit, including the accumulator **454**, is recharged with sufficient pressure to again shift the valve **485** to its fully open position, which then permits unrestricted bypassing and circulating of the hydraulic fluid from the pump through the valve back to the reservoir. Since the valve **485** holds no back pressure, no heat is created and needless overheating of the fluid and wastage of horsepower are prevented.

The conduit **490** constitutes an exhaust line for exhausting fluid from the cylinders for operating the slip assemblies, blowout preventers and gate valves which connect therewith.

The heat exchanger **491** and a filter **492** may be the same as or similar to those employed in the circulating circuit **317** in FIGURE 12.

As a matter of convenience, all of the valves for controlling the operation of the piston, the slip assemblies and the blowout preventers in addition to any other valve controls provided may be mounted on a panel installed at a suitable height above the platform **51** so that an operator on the platform may have control of the entire apparatus at his fingertips.

The structure of the slip assemblies employed in the present apparatus is illustrated in detail in FIGURE 8 which shows the two gripping slip assemblies **24** and **25** comprising the lower stationary snubber **26** shown in FIGURE 1. As shown, the two gripping slip assemblies are mounted in opposed functional relationship so that one assembly can hold the tubing against longitudinal movement in one direction while the other assembly can prevent movement of the tubing in the other direction. While all the slip assemblies incorporated in the apparatus are identical, it is to be noted that they are never all mounted for gripping action in the same direction.

Each slip assembly **24**, **25** and **40** includes a bowl or body **205** having a tapered longitudinal bore **206** extending therethrough, and provided on its opposite ends with external annular hubs **205***a* by means of which the bodies of the slip assemblies may be connected together or to other parts of the assembly. The two slip assemblies **24** and **25**, comprising the stationary snubber **26**, are fastened together by a split clamp ring **201** secured by bolts **202** having nuts **203** thereon, said clamp ring engaging over the abutting annular hubs **205***a* of the two slip assemblies. The slip assembly of the travelling snubber **40** may also be connected to the upper end of the tubular piston rod **32** by an identical clamp ring securing the external annular hub of such assembly to an identical hub on the upper end of the tubular piston rod. Vertical dovetail slots **207** are formed in the internal wall of the body of each of the slip assemblies to receive dovetail keys **208** on which slips **209** are slidably mounted. The slips in each assembly are shown as four in number and, when viewed as a set, are substantially frusto-conical in shape. The outer surfaces of the slips are tapered to conform substantially to the tapered bore **206** of the assembly body and each is provided with a vertical dovetail slot **210** slidable on one of the dovetail keys. Each key is retained in its associated slip body by a lock screw **208***a* which extends through an aperture in the assembly body into the divergent ends of the slots **207**. The slips **209** are slidable longitudinally in the tapered vertical bore **206** of the body and are retained therein by the keys **208** cooperating with the dovetail grooves **210** in the outer surface of each slip. Thus, when the slips are moved toward the small end of the tapered body bore, the slips are cammed inwardly, and when moved in the opposite direction toward the wide end of the bore, they are moved outwardly.

As will be seen in FIGURE 10, the curvature of the outer surfaces of the slips, however, is slightly greater than the curvature of the bore surface of the bowl or body **205**, so that the conformity of the two surfaces is not exact. This permits the slips to be slidably supported by the keys **208** engaging in the slots **210** in the outer surfaces of the slips rather than engage the bore surface

of the body throughout their movement longitudinally in the body, thus reducing friction and avoiding any binding of the lateral edges of the slips with the bore wall as the slips move into the smaller end of the bore of the body.

Each slip **209** is provided with an internal horizontal arcuate dovetailed slot **212** adapted to receive a slip insert **213** having an external arcuate dovetailed rib **213***a* thereon. Gripping teeth **214** are formed on the substantially cylindrical inner surface of the slips for engaging the well tubing when the same is inserted through the slip assemblies. The inserts are locked in place in the slips by set screws **214***a* threaded into a threaded hole drilled and tapped in both the slip and the insert therein.

The movement of the slips toward their outer or retracted positions is limited by their contact with the annular shoulder **215** of the internal flange **216** of the body. In the other direction, movement of the slips is limited by engagement with the tubing or, when no tubing is present in the bore of the body, the inward movement of the slips toward operative tubing engaging or gripping position is limited by the mechanism which actuates the slips or by the engagement of the slips with each other.

It is apparent that when the slips are moved to their outer retracted positions, they will permit passage of the tubing through the bore of the body, and that when they are moved inwardly into gripping engagement with the tubing, they will prevent such passage. It should also be understood that the slips will hold much better against movement of the tubing in one direction than the other. As the tubing is biased in one direction either by well pressure or by gravity, the slip assembly is positioned with the taper of the bore of the bowl and of the slips pointing in the direction of the tubing bias. Thus, the engagement of the tubing with the slips tends to wedge the slips inwardly as they move along the tapered bore of the body to cause even firmer gripping engagement with the tubing, so that the greater the force on the tubing tending to move the tubing, the tighter will be the grip of the slips thereon.

The slips also provide a holding action against tubing movement in the other direction but to a much lesser degree, and the slip assemblies are preferably not used to grip and hold the pipe against movement under such conditions. Instead, the slip assemblies are so disposed that the taper of the bore of the bowl or body and the taper of the slips wedge the slips into tighter gripping engagement with the tubing when the tubing is moved longitudinally by such biasing force acting thereon.

The body **205** is provided with bosses **220** on opposite sides thereof, each having a window **221** opening from the exterior of the body to the bore **206**. A horizontal shaft **222** is mounted in a transverse bore in each of the bosses and extends transversely across the window therein, and each shaft carries a slip pivot arm **223** which extends inwardly through the window into the bore of the body for moving the pair of slips **209** disposed therein adjacent such window. Keys **224** prevent rotation of the pivot arm relative to the shaft. An operating lever **225** is installed externally of the body and connected to one end of each shaft, the shaft being provided with a reduced end portion which extends through an accommodating aperture in one end of the lever. Each lever is retained on its shaft **222** by an end plate **226** and an axial screw **227**, while keys **228** assure that the shaft will be rotated by the operating lever as the same is moved, the slip pivot arm being moved thereby to move the slips, as will be explained. A pair of bearings **229** and **230** are mounted in the bores of each of the bosses **220** on either side of the pivot arm to reduce rotational friction between the shaft and bosses and facilitate movement of the slip pivot arms by swinging movement of the operating levers. Washers **231** reduce the friction between the body and the head **222***a* of the shaft, and a bearing shim **232** spaces the shaft end of each operating lever from the body **205**. The other end of each operating lever **225** is provided with a slot **234**, and a synchronizing pin **235** extends through said slots and has an inner base end **238** slidably mounted in a vertical dovetail slot **236** formed in the external wall of the body. As shown in FIGURES 8 and 9 the base slides in the slot **236** and acts as a guide and to assure smooth vertical reciprocable movement of the pin. Since the pin extends through the slots **234** in both of the operating levers **225**, the levers are linked to move in synchronism when the pin is caused to move up or down.

An up or down movement is imparted to the pin by means of a vertical piston rod **237** which has a bearing member **238***a* at its upper end engaged around the outer end of pin **235** whereby vertical movement of the piston moves the pin therewith, and since the pin is engaged in the slots **234** in the operating levers **225**, also causes the slip pivot arms to swing about the axes of the shafts **222**. The inner free end of each of the pivot arms has a cross-pin portion **223***a* which engages in slots **209***a* formed in the outer portion of the laterally thicker ends of each of the slip **209**. As the slips are moved up and down in the tapered bore **206** on the dovetailed keys **208**, they also move toward and away from one another and the vertical space between them varies considerably. Accordingly, each pivot arm **223** is reduced in thickness near its inner end, as at **223***b*, so that this portion will not be engaged by or prevent movement of the slips when they are moved. Each of the slips is also relieved adjacent the slots **209***a*, as at **209***b* (see FIGURES 8 and 10), to provide room for the reduced portion **223***b* of the pivot arm when the slips are wedged inwardly toward their tubing engaging position by movement toward the reduced portion of the bore of the body.

The piston rod **237** of the lower slip assembly **24** of FIGURE 8 extends downwardly through a gland **240** mounted in the upper end of a hydraulic cylinder **244** secured by bolts **244***a* to the side of the body below the operating levers. A piston **241**, slidably mounted in the bore **243** of the cylinder **244** is connected to the lower end of the piston rod, and the cylinder extends parallel with the longitudinal axis of the body in alignment with the piston rod. The piston is locked on the piston rod by a lock nut **245**. A piston seal ring **242**, disposed in an external annular groove in the piston, seals between the piston and the wall of the bore **243**. Hydraulic operating fluid is conducted into and out of the bore of the cylinder above the piston through a lateral port **247** which is connected by means of a suitable conduit **247***a* with a valve in a hydraulic system, such as the system disclosed in FIGURE 6, while a lateral port **248** at the lower end of the cylinder provides means for conducting hydraulic fluid by means of a conduit **248***a* into and out of the bore of the cylinder below the piston. Introduction of fluid pressure into the cylinder through one of the ports at the same time fluid is conducted out of the cylinder through the other port to the reservoir of the hydraulic system will cause the piston to slidably move within the cylinder. The direction of movement of the piston, of course, is away from whichever port is the fluid inlet port. It is thus apparent that the slip gripping inserts **213** can be engaged with or disengaged from the tubing at will as determined by the introduction of fluid pressure to the chambers on either side of the piston.

It will also be seen that movement of the slips toward tubing engagnig position is, in the absence of tubing, limited by the engagement of the external shoulder **238***b* of the bearing member **238***a* on the piston rod with the adjacent end of the cylinder **244** and the packing gland **240**. Should it be desired to positively lock the slips in gripping engagement with the tubing, a lock screw **250** is threaded into an opening **251** in the exterior of the body **205**, and a cap screw **252** is threaded through an accommodating eye or aperture in the lock screw and tightened against each operating lever **225**, as shown in the upper slip assembly of FIGURE 8, to prevent swinging pivotal move-

ment of such operating lever. By this means, the slip pivot arms are likewise held against swinging movement and, therefore, hold the several slips locked in their tubing engaging position for any desired period of time without the necessity of maintaining fluid pressure in the cylinder **244**.

At the connection of the two slip assemblies **24** and **25**, forming the lower stationary snubber **26**, an annular tubing guide **255** is held in guiding centralizing position in the bore of the two assemblies, as shown in FIGURE 8. The guide includes an external peripheral flange **256** which is positioned in a groove formed between the shoulders **256***a* in the internal bore walls of the assembly bodies **205**. Similar guides may be placed at longitudinally spaced distances in the bore of the apparatus to serve to hold the tubing in alignment with the axis of the apparatus so that the slips and the seal members of the blowout preventers will engage the tubing without difficulty. In addition, the guides serve to prevent the tubing from buckling or bending, thus enabling it to withstand the greater column loads encountered when working with high well pressures.

It will be apparent that the snubbing apparatus, described herein, is readily adaptable to handle tubing of various diameters by replacing the sealing ram inserts of the blowout preventers, the slip inserts **213**, and the guides **255**, with corresponding elements of a size to accommodate the size of tubing to be handled.

It will also be seen that the coaxial arrangement and longitudinal movement of the tubular piston rod and annular piston, through which the length of tubing or pipe to be moved thereby is inserted, and the fact that such tubing or pipe is disposed axially in and gripped by the gripping means carried by the tubular piston rod, provides for the application of a laterally balanced longitudinal force to the tubing or pipe thereby substantially eliminating buckling or bending of the tubing or pipe as the same is forced into the well against pressure.

It will be further be seen from the foregoing description that a fluid pressure operated apparatus for running or pulling a well conductor or tubing under pressure has been provided, and that the apparatus is supportable on the wellhead itself rather than on an elaborate structure footed on the earth's surface, whereby it is particularly adapted for use on offshore or marine wells having no platforms or derricks or other supporting structures. In addition, it will be noted that the control mechanisms for the snubbing device disclosed herein and the personnel for operating the same are also entirely supported by the wellhead.

From the foregoing, it will readily be apparent that the several members connected above the wellhead, including the gate valve, blowout preventers, the stationary snubber, the operator means and the traveling snubber all comprise a body or housing having a longitudinal passage therethrough through which the well pipe or rods or the like are moved, and that the entire housing including the valves, blowout preventers, snubbers and operator means for the snubbers are mounted solely on the wellhead, whereby the wellhead provides a support for all operations conducted in the well by use of such apparatus.

It will further be seen that the lower stationary snubber **26** including the two gripping assemblies **24** and **25**, together with the upper traveling snubber **40** and the hydraulic fluid actuated operator means for effecting longitudinal movement of the traveling snubber toward and away from the stationary snubber constitutes a hydraulically operated snubbing apparatus, and that an improved hydraulic system has been provided for automatically hydraulically locking the snubbing apparatus against longitudinal movement in the event of failure of hydraulic fluid pressure in the system.

It will also be readily apparent that the plurality of blowout preventers comprise a plurality of seal means carried by the housing for moving into and out of sealing engagement with the pipe or rods extending through the housing to effect movement thereof of such pipe or rods through the housing into the well by providing means for passing externally enlarged couplings and the like through the sealing elements of the rams of the blowout preventers.

It will also be seen that the slip assembly disclosed herein, while actuatable in response to application of fluid pressure, may be locked mechanically and held in operative position independently of the fluid pressure.

The foregoing description of the invention is explanatory only, and changes in the details of the construction illustrated and the system described may be made by those skilled in the art, within the scope of the appended claims, without departing from the spirit of the invention.

What is claimed and desired to be secured by Letters Patent is:

1. A snubbing assembly adapted to be mounted solely on a wellhead for controlling the movement of tubing under pressure in a well comprising: a seal assembly mounted on said wellhead having a bore extending therethrough and adapted to sealingly engage a length of tubing extending through said bore to confine the well pressure of said well; and means for applying a laterally balanced longitudinal force to said tubing for holding and running said tubing into or out of said well, said means including; first tubing gripping means having a bore extending therethrough and supported on said seal assembly, said gripping means being adapted to grip said length of tubing received within its axial bore to hold and support the same against longitudinal movement therein; means providing an annular chamber and having an axial bore and supported on said first gripping means; a tubular piston member having an axial bore and disposed within said annular chamber and co-axial therewith, said tubular piston member being mounted in said annular chamber for relative axial longitudinal movement thereof; second tubing gripping means having a bore extending therethrough and mounted on said tubular piston member at an end thereof which is remote from said first gripping means, said second gripping means being adapted to grip said length of tubing inserted in said tubular piston; member means connecting said second gripping means with said piston member for movement of said second gripping means by said piston member longitudinally relative to said chamber, all of said bores being aligned with the bore of said well to define a passage for passage of said length of well tubing therethrough; said first gripping means being engaged with said tubing to hold and support the same against longitudinal movement while said second gripping means is disengaged from said tubing, and said second gripping means being engaged with said tubing for gripping and moving the same longitudinally when said first ripping means is disengaged from said tubing, whereby said tubing may be moved lougitudinally of said bores or said passage; and fluid pressure means for imparting laterally balanced longitudinal movement to said tubular piston member in alternating reciprocal directions whereby said length of tubing received within the bore of said tubular piston member and gripped by said second gripping means may be moved thereby through said passage into or out of the well as determined by the direction of movement imparted to said tubular piston member.

2. A snubbing assembly adapted to be mounted solely on a wellhead for controlling the movement of tubing under pressure in a well comprising: a seal assembly mounted on said wellhead having a bore extending therethrough and adapted to sealingly engage a length of tubing extending through said bore to confine the well pressure of said well; first tubing gripping means having a bore extending therethrough and connected to and supported on said seal assembly, said gripping means being adapted to grip said length of tubing received within its bore to hold the same against longitudinal movement therein; means providing an elongate annular chamber

having an axial bore extending therethrough and connected to and supported on said first gripping means; a tubular piston member having an axial bore and disposed within said annular chamber in co-axial relation therewith, said tubular piston member being mounted within said annular chamber for relative longitudinal axial movement thereof; second tubing gripping means having a bore extending therethrough; an elongate tubular member having one end connected to said piston member in said chamber and the opposite end thereof connected to said second tubing gripping means, said second gripping means being mounted on said tubular member at an end thereof which is remote from said wellhead, said second gripping means being adapted to grip said length of tubing inserted in said tubular member, all of said bores being aligned with the bore of said well to define a passage for said length of well tubing; said first gripping means being engaged with said tubing to hold and support the same against longitudinal movement while said second gripping means is disengaged therefrom, and said second gripping means being engaged with said tubing for gripping and moving the same longtudinally when said first gripping means is disengaged therefrom, whereby said tubing may be moved longitudinally of said passage; and means for imparting axial movement to said tubular piston member in alternating reciprocal directions whereby said length of tubing received within the bore of said means forming said annular chamber and the bore of said tubular member and gripped by said second gripping means may be moved through said passage into or out of said well as determined by the direction of movement imparted to said tubular piston member.

3. A gripping assembly comprising: a body having a bore extending therethrough: a plurality of gripping means movable on said body between a retracted position and an inward operative position wherein said gripping means are engageable with an elongate member received in said bore to grip said elongate member; means on said body responsive to fluid pressure to alternately move said gripping means between said retracted and said operative positions; and locking means on said body engageable with said means for moving said gripping means between retracted and operative positions for locking said gripping means in said operative position.

4. A gripping assembly for gripping elongate objects comprising: a body having a bore extending therethrough; a plurality of gripping means movable on said body between a retracted position and an inward operative position wherein said gripping means are engageable with an elongate object received in said bore to grip said elongate object; means on said body responsive to fluid pressure to alternately move said gripping means between said retracted and said operative positions; locking means on said body engageable with said means for moving said gripping means between retracted and operative positions for locking said gripping means in said operative position; and means on said body and said locking means coengageable for moving said locking means into engagement with said means for moving said gripping means to lock said gripping means in gripping position independently of the maintenance of said fluid pressure.

5. A gripping assembly comprising: a body having a bore having means therein providing a plurality of tapered camming surfaces; a plurality of gripping means slidably supported on the camming surfaces in said bore for movement between an outer retracted position and an inner operative position wherein said gripping means are adapted to engage and grip an elongate object in said bore; means on said body responsive to fluid pressure to alternately move said gripping means along said camming surfaces between said retracted and operative positions; and lock means on said body movable into engagement with said means for moving said gripping means between retracted and operative positions independent of fluid pressure for moving said gripping means between retracted and operative positions to lock said gripping means in said operative position.

6. A gripping assembly for gripping a length of tubing comprising: a body having a bore extending therethrough; the wall of said bore being provided with a plurality of circumferentially spaced longitudinally extending camming surfaces; a plurality of circumferentially spaced gripping means each slidably movable on one of said camming surfaces between an outer retracted position and an inner operative position wherein said gripping means is adapted to engage and grip a length of tubing inserted in said bore, said camming surfaces and complementary gripping means being disposed in circumferentially spaced pairs; means operatively connecting adjacent pairs of said gripping means for movement in pairs along said camming surfaces; means on said body actuable by application of fluid pressure operatively connected with said connecting means for movement of said connecting means to move said pairs of gripping means along said camming surfaces between said retracted and said operative positions.

7. A gripping assembly for gripping a length of well tubing comprising: a support member having a bore communicating at both ends with the exterior of said support member; a plurality of tapered longitudinally extending circumferentially spaced camming members in said support member bore; a plurality of circumferentially spaced gripping means movably mounted in said support member and each supported in camming engagement with a separate one of the camming members in said bore; said gripping means being movable within said bore between an outer retracted position and an inner operative position wherein said gripping means are adapted to engage a length of well tubing inserted in said bore, said gripping means and complementary camming members being disposed in circumferentially spaced pairs; connecting means operatively connecting adjacent pairs of said gripping means for movement of each of said pairs of gripping means as a unit on said camming members; means on said support member operatively associated with said connecting means and responsive to fluid pressure for alternately moving said connecting means to move the pairs of gripping means operatively connected therewith between said retracted and operative positions.

8. A gripping assembly for gripping a length of well tubing comprising: a support member having a tapered bore communicating at both ends with the exterior of said support member; a plurality of circumferentially spaced longitudinally extending supporting keys in said bore disposed in an inwardly and downwardly converging position with respect to each other; gripping means movably mounted on said supporting keys and slidable longitudinally thereon on said keys within said tapered bore between an outer retracted position and an inner operative gripping position wherein said gripping means is adapted to engage a length of well tubing inserted in said bore; means on said support member responsive to fluid pressure for alternately moving said gripping means between said retracted and operative positions; and lock means on said support member engageable with said means for moving said gripping means between retracted and operative positions for locking said gripping means in said operative position.

9. An apparatus for moving pipe or rods comprising: a pair of co-axial cylinders defining an annular chamber therebetween, the inner one of said cylinders having a bore extending therethrough; first fixed gripping means secured to the outer cylinder and having means thereon providing for connection thereof to a well flow conductor and operable for gripping a pipe or rod extending through said inner cylinder; means for moving said first gripping means into and out of position for gripping said pipe or rod to prevent longitudinal movement thereof; an annular piston slidably mounted in said annular chamber for longitudinal movement relative to said cylinders; means for applying

fluid pressure against a selected side of said piston to impart movement thereto within said annular chamber; second gripping means connected with said piston and operable for gripping a pipe or rod disposed within said inner cylinder bore; fluid pressure operated means for moving said second gripping means into and out of position for gripping said pipe or rod; elongate piston rod means connecting said second gripping means and said piston whereby said second gripping means is connected to said piston to move therewith toward and away from said first gripping means whereby said length of pipe or rod disposed in said bore may be moved therethrough in a direction determined by the direction of movement imparted to said piston.

10. An apparatus of the character set forth in claim **9** wherein said piston rod means comprises an elongate annular sleeve disposed axially in and movable longitudinally of said annular chamber connecting said annular piston with said gripping means, means on said cylinders and said sleeve coengageable during longitudinal movement of sleeve, whereby such axial mounting of said sleeve in said chamber provides for application of a laterally balanced longitudinal force to said gripping means longitudinally of the bore of said inner cylinder.

11. An apparatus for moving pipe or rods comprising: a pair of co-axial cylinders defining an annular chamber therebetween, the inner one of said cylinders having a bore extending therethrough, an annular piston slidably mounted in said annular chamber for longitudinal movement relative to said cylinders; means for applying fluid pressure against a selected side of said piston to impart movement thereto within said annular chamber; first fixed gripping means secured to the outer of said cylinders and having means thereon providing for connection thereof to a well flow conductor and operable for gripping a pipe or rod extending through said inner cylinder; means for moving said first gripping means into and out of position for gripping said pipe or rod to prevent longitudinal movement thereof; second gripping means alternately operable for gripping and releasing a pipe or rod disposed within said inner cylinder bore; fluid pressure operated means for moving said second gripping means between gripping and releasing positions; means connecting said second gripping means to said piston to move therewith whereby said length of pipe or rod disposed in said bore may be moved therethrough in a direction determined by the direction of movement imparted to said piston; and means acting on said piston to positively hold the same against movement in said annular chamber to prevent undesired longitudinal movement of said second gripping means connected with said piston relative to said chamber.

12. An apparatus for moving pipe or rods comprising: a pair of co-axial cylinders defining an annular chamber therebetween, the inner one of said cylinders having a bore extending therethrough; an annular piston slidably mounted in said annular chamber for longitudinal movement relative to said cylinders; means for applying fluid pressure against a selected side of said piston to impart movement thereto within said annular chamber; first fixed gripping means secured to the outer of said cylinders and having means thereon providing for connection thereof to a well flow conductor and operable for gripping a pipe or rod extending through said inner cylinder; means for moving said first gripping means into and out of position for gripping said pipe or rod to prevent longitudinal movement thereof; second gripping means alternately operable for gripping and releasing a pipe or rod disposed within said inner cylinder bore; fluid pressure operated means for moving said second gripping means between gripping and releasing positions; means connecting said second gripping means to said piston to move therewith whereby said length of pipe or rod disposed in said bore may be moved therethrough in a direction determined by the direction of movement imparted to said piston; and fluid pressure control means controlling the fluid pressure acting on said piston to positively hold said piston against longitudinal movement in said chamber to prevent undesirable longitudinal movement of said second gripping means connected with said piston relative to said chamber.

13. An apparatus for moving pipe or rods comprising: a pair of co-axial cylinders defining an annular chamber therebetween, the inner one of said cylinders having a bore extending therethrough; first fixed gripping means secured to one end of the outer of said cylinders and having means adapted for connecting the same to a well flow conductor and operable to grip a pipe or rod disposed within the bore of the inner cylinder to prevent longitudinal movement of said pipe or rod; means for operating said first gripping means into and out of gripping position; an annular piston slidably mounted in said annular chamber for longitudinal movement relative to said cylinders; means for applying fluid pressure against a selected side of said piston to impart movement thereto within said annular chamber; second gripping means for gripping a pipe or rod disposed within said inner cylinder bore; means connecting said second gripping means with said piston to move said second gripping means longitudinally with said piston toward and away from said fixed gripping means; and means for actuating said second gripping means into and out of gripping engagement with said pipe or rod whereby said pipe or rod disposed in said bore may be moved therethrough in a direction determined by the direction of movement imparted to said piston.

14. An apparatus for moving elongate objects comprising: a pair of co-axial cylinders defining an annular chamber therebetween, the inner one of said cylinders having a bore extending therethrough; an annular piston slidably mounted in said annular chamber for longitudinal movement relative to said cylinders; means communicating with said annular chamber for introducing fluid pressure therein at opposite sides of said piston; control means for varying the fluid pressure on opposite sides of the piston to move said piston in a selected longitudinal direction of said cylinder; first fixed gripping means secured to one end of the outer one of said cylinder and having means thereon adapted for connection with a well flow conductor and operable to grip an elongate object disposed within the bore of said inner cylinder to prevent longitudinal movement of said elongate object; fluid pressure means for actuating said first gripping means into and out of position for gripping said elongate object to hold the same against movement relative to said outer cylinder and said chamber; second gripping means selectively operable for gripping an elongate object disposed within said inner cylinder bore; means for actuating said second gripping means into and out of position for gripping said elongate object; and means connecting said second gripping means to said piston to move therewith longitudinally toward and away from said first fixed gripping means whereby said elongate object disposed in said bore may be moved therethrough in a direction determined by the direction of movement imparted to said piston.

15. A snubbing apparatus for moving pipe or rods into and out of a well including: a stationary snubber; a traveling snubber; hydraulic fluid pressure actuated operator means connecting said stationary snubber and said traveling snubber and actuatable to move said traveling snubber toward and away from said stationary snubber, said operator means including a cylinder and a piston movable therein by hydraulic fluid pressure; and a hydraulic system for controlling reciprocal movements of said piston longitudinally in said cylinder comprising a source of fluid pressure; means for selectively communicating said pressure to either side of the piston within said cylinder; a first valve means operable to exhaust the fluid in said cylinder on one side of said piston; a second valve means operable to exhaust the fluid in said cylinder on the other side of said piston; and means for communicating fluid pressure from said source to the one of said valve means

which controls the exhaust of fluid from said cylinder on the side of the piston opposite that to which fluid pressure is selectively applied, each of said valve means being operable in response to predetermined fluid pressure communicated thereto from said source, whereby such predetermined fluid pressure is required to open said one valve means to permit exhausting of fluids from the cylinder and whereby said one valve means closes when said pressure falls below said predetermined pressure to prevent further movement of said piston within said cylinder.

16. An apparatus for moving pipe or rods into and out of a well under pressure, said well being provided with a wellhead and having a pipe or rod extending therethrough into said well, said apparatus including: a housing defining an elongate passage; means at the lower end of the housing for connecting and supporting said housing solely on said wellhead with said passage in alignment with the bore of the well; a plurality of seal means spaced longitudinally of and carried by said housing and movable into and out of sealing engagement with said pipe or rod when the same is disposed in said passage to prevent fluid flow from the well through said passage externally of said pipe or rod past said seal means; and means for applying a laterally balanced longitudinal force to said pipe or rod for holding and moving said pipe or rod into and out of said well, said means incuding: a first gripping means carried by said housing for gripping said pipe or rod when disposed in said passage to hold and support the same against longitudinal movement; a pair of coaxial cylinders defining an annular chamber therebetween and forming a part of said housing and having a bore in axial alignment with the bore of the well; an annular piston slidably mounted in said annular chamber for longitudinal movement relative to said cylinders; means for applying fluid pressure against a selected side of said piston to effect movement thereof with respect to said annular chamber; an annular piston rod connected with said annular piston and extending upwardly therefrom out of said annular chamber; a second gripping means for gripping pipe or rod disposed in said passage carried on the projecting end of said piston rod and movable therewith, whereby movement of the piston and the piston rod connected therewith causes longitudinal movement of said second gripping means relative to said first gripping means; said first gripping means being engaged with said pipe or rod to hold and support the same against longitudinal movement while said second gripping means is disengaged from said tubing, and said second gripping means being engaged with said tubing for gripping and moving the same longitudinally when said first gripping means is disengaged from said tubing, whereby said tubing may be moved longitudinally of said passage; and hydraulic control means for controlling the introduction of hydrauic fluid pressure into said annular chamber to effect movement of said piston and the second gripping means connected therewith, the axial mounting of the tubular piston rod in the annular cylinder having the bore therethrough receiving the pipe or rod and applying a longitudinal laterally balanced force through said second gripping means to said pipe or rod to move the same into the well bore.

17. A snubbing apparatus for moving elongate objects longitudinally with a longitudinal laterally balanced force and comprising: a pair of coaxial cylinders defining an annular chamber therebetween, the inner one of said cylinders having a bore extending therethrough for receiving the elongate object to be moved; an annular piston slidably mounted in said annular chamber for longitudinal movement relative to said cylinders; a tubular connecting rod connected at one end with said annular piston and extending therefrom beyond the end of the annular chamber defined by the coaxial cylinders; gripping means carried by said projecting end of said tubular piston rod, said gripping means being hydraulically operated for gripping an elongate object disposed within said inner cylinder bore and within said tubular piston rod; conduit means connected with said annular chamber on opposite sides of said piston for introducing hydraulic fluid pressure into said chamber for effecting longitudinal movement of the piston in said chamber whereby the gripping means is moved longitudinally with said piston by means of the piston rod connecting the two; control means in said conduit means for varying the fluid pressure on opposite sides of the piston to move said piston in a selected longitudinal direction in said cylinders; and a second gripping means on the opposite end of said cylinders and connected therewith for gripping said elongate object to hold the same against movement while the movable first gripping means is being moved to position for re-engagement with said elongate object.

18. A snubbing apparatus of the character described in claim 17 wherein the control means for varying the fluid pressure on opposite sides of the piston to move said piston comprises a source of fluid pressure, a valve means connected in said conduit means operable to exhaust the fluid in said cylinder and said chamber on one side of said piston; a first valve means and second valve means in said conduit means operable to direct fluid pressure from said source into said chamber on said opposite side of said piston to cause movement of said piston in said chamber, said first valve means being operable in response to a predetermined fluid pressure communicated thereto from said source to permit fluid to be expelled from said chamber and to close when said fluid pressure applied to said first valve means falls below said predetermined value, whereby movement of the piston is stopped.

19. A snubbing apparatus for moving pipe or rods into and out of a well including: a stationary snubber; a traveling snubber; hydraulic fluid pressure actuated operator means connecting said stationary snubber and said traveling snubber and actuatable to move said traveling snubber toward and away from said stationary snubber, said operator means including an annular cylinder and a piston movable therein by hydraulic fluid pressure and having means connecting it with said travelling snubber whereby said traveling snubber is movable with said piston; and a hydraulic system for controlling reciprocal movements of said piston longitudinally in said cylinder comprising: a source of fluid pressure; conduit means communicating said pressure from said source to each side of the piston within said cylinder; a first valve means in said conduit means operable to exhaust the fluid in said cylinder on one side of said piston; a second valve means in said conduit means operable to exhaust the fluid in said cylinder on the other side of said piston; means for communicating fluid pressure from said source to the one of said valve means which controls the exhaust of fluid from said cylinder on the side of the piston opposite that to which fluid pressure is selectively applied, said valve means being operable in response to predetermined fluid pressure communicated thereto from said source, whereby such predetermined fluid pressure is required to open said one valve means to permit exhausting of fluids from the cylinder and whereby said one valve means closes when said pressure falls below said predetermined pressure to prevent further movement of said piston within said cylinder; and seal means between said operator means and said well pipe or rods.

20. An apparatus for moving under pressure pipe or rods into and out of a well provided with a wellhead and having a pipe or rod extending thereinto, said apparatus including: a housing defining an elongate passage; means at the lower end of the housing for connecting and supporting said housing solely on a wellhead with said passage in communication with the bore of the well; a plurality of longitudinally spaced seal means carried by said housing for moving into and out of sealing engagement with said pipe or rod when disposed in said passage to prevent fluid flow from the well through said passage past said seal means externally of said pipe or rod; a first

gripping means carried by said housing above said plurality of seal means for gripping said pipe or rod disposed in said passage to hold the same against longitudinal movement therein; a second gripping means for gripping said pipe or rod disposed in said passage, said second gripping means being longitudinally spaced above said first gripping means and movable longitudinally of said housing relative thereto; means supported by said housing for supporting and moving said second gripping means relative to said first gripping means; said first gripping means being engaged with said pipe or rod to hold and support the same against longitudinal movement while said second gripping means is disengaged from said pipe or rod, and said second gripping means being engaged with said pipe or rod for gripping and moving the same longitudinally of the housing when said first gripping means is disengaged from said pipe or rod, whereby said pipe or rod may be moved longitudinally of said housing by said second gripping means; and means for actuating said means for moving said second gripping means, for actuating said seal means, and for actuating said gripping means, each independently of the other, whereby said seal means and said gripping means may be moved into and out of engagement with said length of pipe or rod disposed in said passage and said means for moving said second gripping means may be operated to move said second gripping means so that said pipe or rod may be moved through said passage under pressure into or out of said well.

21. An apparatus for moving under pressure pipe or rods into and out of a well provided with a wellhead and having a pipe or rod extending thereinto, said apparatus including: a housing defining an elongate passage; means at the lower end of the housing for connecting and supporting said housing on said wellhead with said passage in communication with the bore of the well; a plurality of seal means spaced longitudinally of and carried by said housing for moving into and out of sealing engagement with said pipe or rod when disposed in said passage to prevent fluid flow from the well through said passage externally of said pipe or rod past said seal means; a first means carried by said housing for gripping said pipe or rod disposed in said passage for holding and supporting said pipe or rod against longitudinal movement therein; a pair of coaxial cylinders defining an annular chamber therebetween and supported on said housing in axial alignment with the bore of said well; an annular piston slidably mounted in said annular chamber for longitudinal movement relative to said cylinders; means for applying fluid pressure against a selected side of said piston to impart movement thereto within said annular chamber; a second gripping means for gripping said pipe or rod disposed in said passage; means connecting said second gripping means to said piston to move therewith; said first gripping means being engaged with said pipe or rod to hold and support the same against longitudinal movement while said second gripping means is disengaged from said pipe or rod, and said second gripping means being engaged with said pipe or rod for gripping and moving the same longitudinally of the housing when said first gripping means is disengaged therefrom, whereby said pipe or rod may be moved longitudinally of said housing by said second gripping means; means for actuating said means for applying fluid pressure against said piston, for actuating said seal means, and for actuating said gripping means, each independently of the other, whereby said seal means and said gripping means may be moved into and out of engagement with said length of pipe or rod disposed in said passage and said means for applying fluid pressure against said piston to move the same may be actuated to move said piston and the second gripping means carried thereby for moving the same longitudinally, whereby said pipe or rod may be moved through said passage and into or out of said well as determined by the direction of movement imparted to said piston.

22. An apparatus of the character set forth in claim 21 wherein said means for connecting said piston with said second gripping means comprises: an elongate tubular sleeve disposed axially in and movable longitudinally of said annular chamber connecting said annular piston with said second gripping means, such axial mounting of said sleeve in said chamber between said cylinders providing for application of a laterally balanced longitudinal force to said second gripping means.

23. In an apparatus of the character set forth in claim 21 for moving pipe or rods into and out of a well, a hydraulic system for controlling reciprocal movements of said piston slidably mounted in said annular chamber comprising: a source of fluid pressure; means communicating said pressure to one side of the piston within said annular chamber; valve means operable to exhaust the fluid in said annular chamber on the other side of said piston; and means for communicating fluid pressure from said source to said valve means, said valve means being operabale in response to a predetermined level of fluid pressure communicated thereto from said source.

24. In an apparatus of the character set forth in claim 21 for moving pipe or rods into and out of a well, a hydraulic system for controlling reciprocal movements of said hydraulic pressure operated pipe engaging and moving means including said annular chamber and said piston slidably mounted in said annular chamber and comprising: a source of fluid pressure; means communicating said pressure to one side of the piston within said annular chamber; a normally closed valve means operable to exhaust the fluid in said annular chamber on the other side of said piston to said source, and means for communicating fluid pressure from said source to said valve means, whereby said valve means is opened in response to a predetermined fluid pressure communicated thereto from said source to permit the flow of fluids from said annular chamber and whereby said valve means is closed when said fluid pressure communicated to said valve means falls below said predetermined pressure.

25. An apparatus for moving under pressure elongate objects into and out of a well provided with a wellhead and having an elongate object extending therethrough into said well, said apparatus including: a housing defining an elongate passage; means at the lower end of the housing for connecting and supporting said housing solely on a wellhead with said passage in alignment with the bore of the well; a plurality of longitudinally spaced seal means carried by said housing for moving into and out of sealing engagement with said elongate object disposed in said passage to prevent fluid flow from the well through said passage past said seal means externally of said elongate object; a first gripping means carried by said housing above said plurality of seal means for gripping said elongate object disposed in said passage to hold said object against longitudinal movement in said passage; a second gripping means for gripping said elongate object disposed in said passage, said second gripping means being longitudinally spaced from and above said first gripping means and movable relative thereto longitudinally of said housing; means supported by said housing and connected with said second gripping means for supporting and moving said second gripping means longitudinally relative to said first gripping means; said first gripping means being engaged with said elongate object to hold and support the same against longitudinal movement while said second gripping means is disengaged therefrom, and said second gripping means being engaged with said elongate object for gripping and moving the same longitudinally of the passage when said first gripping means is disengaged therefrom, whereby said elongate object may be moved longitudinally of said passage; and means for actuating said means for moving said second gripping means longitudinally, for actuating said seal means and for actuating said gripping means, each independently of the other, whereby said seal means and

said gripping means may be moved into and out of engagement with said elongate object disposed in said passage and said means for moving said second gripping means may be operated to move said second gripping means so that said elongate object may be moved longitudinally through said passage and into or out of said well.

26. A snubbing assembly adapted to be mounted solely on the wellhead for controlling the movement of tubing under pressure in a well comprising: a seal assembly mounted on said wellhead having a bore extending therethrough and adapted to sealingly engage a length of tubing extending through said bore to confine the pressure of said well; first tubing gripping means having a bore extending therethrough and connected to and supported on said seal assembly, said gripping means being adapted to grip said length of tubing inserted in the bore thereof to hold the same against longitudinal movement; a pair of co-axial cylinders defining an annular chamber therebetween and connected to and supported on said first gripping means, the inner one of said cylinders having a bore extending therethrough; an annular piston slidably mounted in said annular chamber for longitudinal movement relative to said cylinders; a tubular piston rod secured to said piston and disposed about said inner cylinder in co-axial relation therewith and extending upwardly out of the upper end of said annular chamber; second tubing gripping means mounted on the projecting end of said tubular piston rod remote from said wellhead, said second gripping means being adapted to grip said length of tubing inserted in the bore of said inner cylinder, all of said bores being aligned with the bore of said well to form a passage for said length of tubing; said first gripping means being engaged with said tubing to hold and support the same against longitudinal movement while said second gripping means is disengaged therefrom, and said second gripping means being engaged with said tubing for gripping and moving the same longitudinally of said passage when said first gripping means is disengaged therefrom, whereby said tubing may be moved longitudinally of said passage by said second gripping means; means communicating with said outer cylinder for applying fluid pressure against a selected side of said piston to impart movement thereto within said annular chamber to move said tubular piston rod and said second gripping means connected thereto, whereby said length of tubing inserted within the bore of said inner cylinder and gripped by said second gripping means may be moved through said passage in a direction determined by the direction of movement imparted to said tubular piston rod.

27. In an apparatus of the type set forth in claim **26** for moving pipe or rods into and out of a well, a hydraulic system for controlling reciprocal movements of said piston slidably mounted in said annular chamber comprising: means for selectively communicating fluid pressure to either side of the piston within said annular chamber; a first valve means operable to exhaust fluid in said annular chamber on one side of the piston; a second valve means operable to exhaust fluid in said chamber on the other side of said piston; bias means for biasing said first and second valve means to normally closed position; and means for communicating fluid pressure to a selected one of said valve means to act in opposition to said bias means whereby said selected valve means is opened in response to a predetermined value of fluid pressure communicated thereto, thereby permitting the exhausting of fluids from said annular chamber on a selected side of said piston and whereby said selected valve means is closed when the fluid pressure communicated thereto falls below said predetermined value to prevent further movement of the piston within the annular chamber.

28. In an apparatus of the character set forth in claim **26** for moving pipe or rods into and out of a well, a hydraulic system for controlling reciprocal movements of said piston and piston rod slidably mounted in said annular chamber and wherein the piston rod is secured to one side of the piston and slidably extends from one end of the annular chamber and said second pipe or rod gripping means is carried by said extending end of said piston rod, said hydraulic system comprising: means for selectively communicating fluid pressure to the chamber portions defined by said annular chamber on opposite sides of said piston; means for transferring fluid from one of said chamber portions to the other to cause movement of said piston within said annular chamber; and means for receiving and storing the excess of fluid which is exhausted from the chamber portion on the side of said piston opposite said piston rod when fluid is transferred therefrom to the other of said chamber portions.

29. In an apparatus of the character set forth in claim **26** for moving pipe or rods into and out of a well, a hydraulic system for controlling reciprocal movements of said piston and piston rod slidably mounted in said annular chamber and wherein the piston rod is secured to one side of the piston and slidably extends from one end of the annular chamber and said second gripping means is carried by said extending end of said piston rod, said hydraulic system comprising: means for selectively communicating fluid pressure to the chamber portions defined by said annular chamber on opposite sides of said piston; means for transferring fluid from one of said chamber portions to the other of said chamber portions to cause movement of said piston within said annular chamber; and means for supplying additional fluid to the chamber portion on the side of said piston opposite said piston rod when fluid is transferred thereto from the other of said chamber portions.

30. A snubbing assembly adapted to be mounted solely on the wellhead for controlling the movement of tubing under pressure in a well comprising: a seal assembly mounted on said wellhead having a bore extending therethrough and adapted to sealingly engage a length of tubing extending through said bore to confine the pressure of said well; first tubing gripping means having a bore extending therethrough and connected to and supported on said seal assembly; said gripping means being adapted to grip said length of tubing inserted in the bore thereof to hold the same against longitudinal movement; a pair of co-axial cylinders defining an annular chamber therebetween and connected to and supported on said first gripping means, the inner one of said cylinders having a bore extending therethrough; an annular piston slidably mounted in said annular chamber for longitudinal movement relative to said cylinders; a tubular piston rod secured to said piston and disposed about said inner cylinder in co-axial relation therewith and extending upwardly out of the upper end of said annular chamber; second tubing gripping means mounted on the projecting end of said tubular piston rod remote from said wellhead; said second gripping means being adapted to grip said length of tubing inserted in the bore of said inner cylinder, all of said bores being aligned with the bore of said well to form a passage for said length of tubing; said first gripping means being engaged with said tubing to hold and support the same against longitudinal movement while said second gripping means is disengaged therefrom, and said second gripping means being engaged with said tubing for gripping and moving the same longitudinally of said passage when said first gripping means is disengaged therefrom, whereby said tubing may be moved longitudinally of said passage by said second gripping means; means communicating with said outer cylinder for applying fluid pressure against a selected side of said piston to impart movement thereto within said annular chamber whereby said length of tubing inserted within the bore of said inner cylinder and gripped by said second gripping means may be moved through said passage in a direction determined by the direction of movement imparted to said tubular piston rod; and second means communicating with said annular chamber for applying fluid pressure against the side of said piston opposite said selected side to impart movement thereto

in an opposite direction within said annular chamber to move said tubular piston rod and said second gripping means in an opposite direction, whereby said length of tubing may be moved in said opposite direction.

31. An apparatus for moving elongate objects into and out of a well provided with a wellhead and having an elongate object extending therethrough into said well, said apparatus including: an elongate housing providing an elongate passage; means at the lower end of the housing for connecting and supporting said housing solely on said wellhead with said passage in alignment with the bore of the well; a plurality of longitudinally spaced seal means carried by and secured to the housing and movable into and out of sealing engagement with said elongate object disposed in said passage to prevent fluid flow from the well through the passage past said seal means externally of said elongate object; a first gripping means carried by said housing above said plurality of seal means for gripping said elongate object disposed in said passage to hold said object against longitudinal movement; a second gripping means movably carried on said housing for gripping said elongate object disposed in said passage, said second gripping means being longitudinally spaced from and above said first gripping means and being movable relative thereto longitudinally of said housing; fluid pressure operated means supported by said housing and connected with said second gripping means for moving said second gripping means longitudinally of said housing relative to said first gripping means; said first gripping means being engaged wth said elongate object to hold and support the same against longitudinal movement while said second gripping means is disengaged therefrom, and said second gripping means being engaged with said elongate object for gripping and moving the same longitudinally of the passage when said first gripping means is disengaged therefrom, whereby said elongate object may be moved longitudinally of said passage; and means for actuating said fluid pressure operated means for moving said second gripping means longitudinally of said housing, for actuating said seal means, and for actuating said gripping means, each independently of the other, whereby said seal means and said gripping means may be moved into and out of engagement with said elongate object disposed in said passage and said means for moving said second gripping means longitudinally of said housing may be operated to move said gripping means so that said elongate object may be moved longitudinally through said passage into or out of said well under pressure.

32. An apparatus for moving under pressure pipe or rods into and out of a well provided with a wellhead and having a pipe or rod extending thereinto, said apparatus including: a housing defining an elongate passage; means at the lower end of the housing for connecting and supporting said housing solely on a wellhead with said passage in communication with the bore of the well; a plurality of longitudinally spaced seal means carried by said housing for moving into and out of sealing engagement with said pipe or rod when disposed in said passage to prevent fluid flow from the well through said passage past said seal means externally of said pipe or rod; a first gripping means carried by said housing for gripping said pipe or rod disposed in said passage to hold the same against longitudinal movement therein; a second gripping means for gripping said pipe or rod disposed in said passage, said second gripping means being longitudinally spaced from said first gripping means and movable longitudinally of said housing relative thereto; means supported by said housing for supporting and moving said second gripping means relative to said first gripping means; said first gripping means being engaged with said pipe or rod to hold and support the same against longitudinal movement while said second gripping means is disengaged from said pipe or rod, and said second gripping means being engaged with said pipe or rod for gripping and moving the same longitudinally of the housing when said first gripping means is disengaged from said pipe or rod, whereby said pipe or rod may be moved longitudinally of said housing by said second gripping means; means for actuating said means for moving said second gripping means, for actuating said seal means, and for actuating said gripping means, each independently of the other, whereby said seal means and said gripping means may be moved into and out of engagement with said length of pipe or rod disposed in said passage and said means for moving said second gripping means may be operated to move said second gripping means so that said pipe or rod may be moved through said passage under pressure into or out of said well; and a hydraulic system for controlling reciprocal movements of said means for moving said second gripping means and including an annular cylinder and an elongate tubular piston slidably mounted in said cylinder and having one end thereof extending upwardly out of said annular cylinder and connected with said second gripping means, and system comprising: a source of fluid pressure; conduit means communicating said pressure to each side of the piston within said cylinder; a first valve means in said conduit means operable to exhaust the fluid in said cylinder on one side of said piston; a second valve means in said conduit means operable to exhaust the fluid in said cylinder on the other side of said piston; and means for communicating fluid pressure from said source to the one of said valve means which controls the exhaust of fluid from said cylinder on the side of the piston opposite that to which fluid pressure is selectively applied, said valve means being operable in response to a predetermined fluid pressure communicated thereto from said source.

33. An apparatus for moving pipe or rods comprising: a pair of co-axial cylinders defining an annular chamber therebetween, the inner one of said cylinders having a bore extending therethrough; an annular piston slidably mounted in said annular chamber for longitudinal movement relative to said cylinders; means for applying fluid pressure against a selected side of said piston to impart movement thereto within said annular chamber; gripping means connected with said piston and operable for gripping a pipe or rod disposed within said inner cylinder bore; fluid pressure operated means for moving said gripping means into and out of position for gripping said pipe or rod; elongate piston rod means connecting said gripping means and said piston whereby said gripping means is connected to said piston to move therewith whereby a length of pipe or rod disposed in said bore may be moved therethrough in a direction determined by the direction of movement imparted to said piston; and seal means connected to the lower end of said co-axial cylinders below said gripping members and having a bore therethrough, and sealing members movable thereon between a position spaced from said pipe or rod in a position sealing against said pipe or rod to prevent fluid pressure passing in either direction longitudinally of said pipe or rod below said cylinders.

34. An apparatus for moving pipe or rod comprising: a pair of co-axial cylinders defining an annular chamber therebetween, the inner one of said cylinders having a bore extending therethrough; an annular piston slidably mounted in said annular chamber for longitudinal movement relative to said cylinders; means for applying fluid pressure against a selected side of said piston to impart movement thereto within said annular chamber; gripping means connected with said piston and operable for gripping a pipe or rod disposed within said inner cylinder bore; fluid pressure operated means for moving said gripping means into and out of position for gripping said pipe or rod; elongate piston rod means connecting said gripping means and said piston whereby said gripping means is connected to said piston to move therewith whereby a length of pipe or rod disposed in said bore may be moved therethrough in a direction determined by the direction of movement imparted to said piston; a seal assembly connected to the lower end of said pair of co-axial cylinders below said gripping members and having a bore therethrough and

having means at the lower end of said seal assembly for connecting the same to the upper end of a well casing; and sealing means movable in said seal assembly between a position in sealing engagement with the pipe or rod to be moved by said gripping means and a position out of said sealing engagement with said pipe or rod whereby said sealing means prevents the escape of well fluids from the well casing externally of said pipe or rod while said pipe or rod is being moved by said gripping means.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,215,203 November 2, 1965

Phillip S. Sizer

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 72, for "snugging" read -- snubbing --; column 13, line 68, for "assembly" read -- assemblies --; column 16, line 64, for "engagnig" read -- engaging --; column 18, line 53, for "ripping" read -- gripping --; column 19, line 59, after "means", second occurrence, insert -- between retracted and operative positions --; column 26, line 19, for "operabale" read -- operable --.

Signed and sealed this 21st day of June 1966.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents