

March 13, 1956

J. LYNES
OIL WELL TOOL

2,738,013

Filed Sept. 5, 1952

8 Sheets-Sheet 1

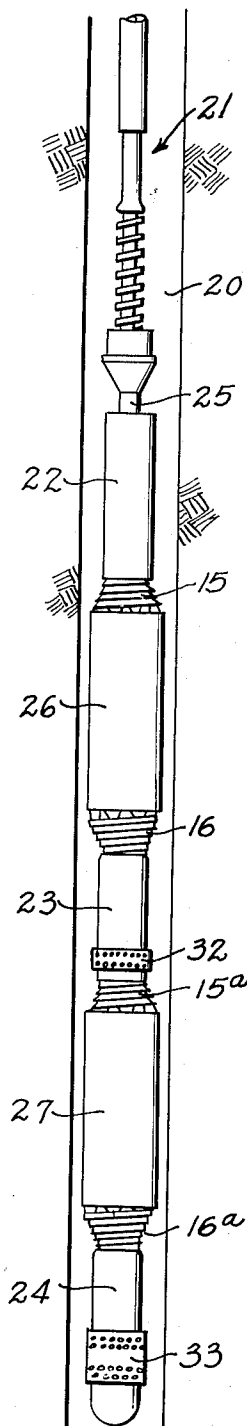


Fig. 1

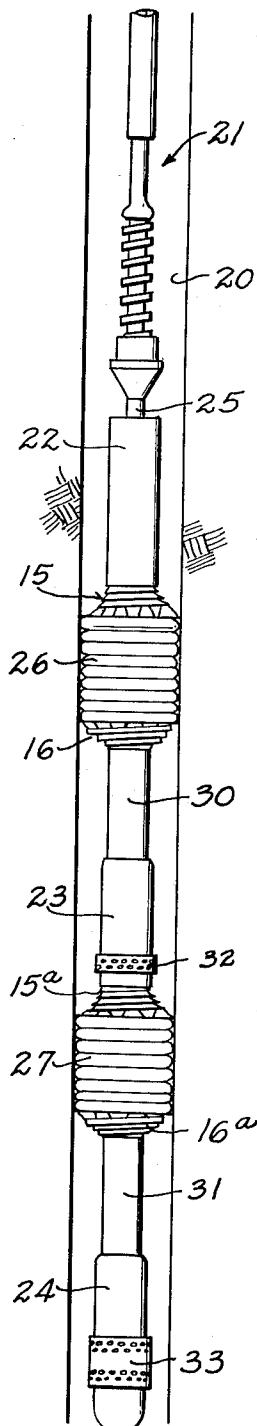


Fig. 2

BY

Mauro & Lewis,

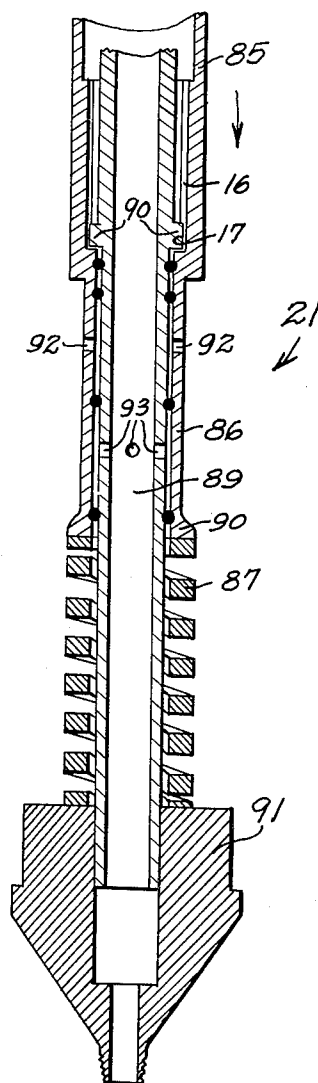


Fig. 3

INVENTOR:
John Lynes,

ATTORNEYS

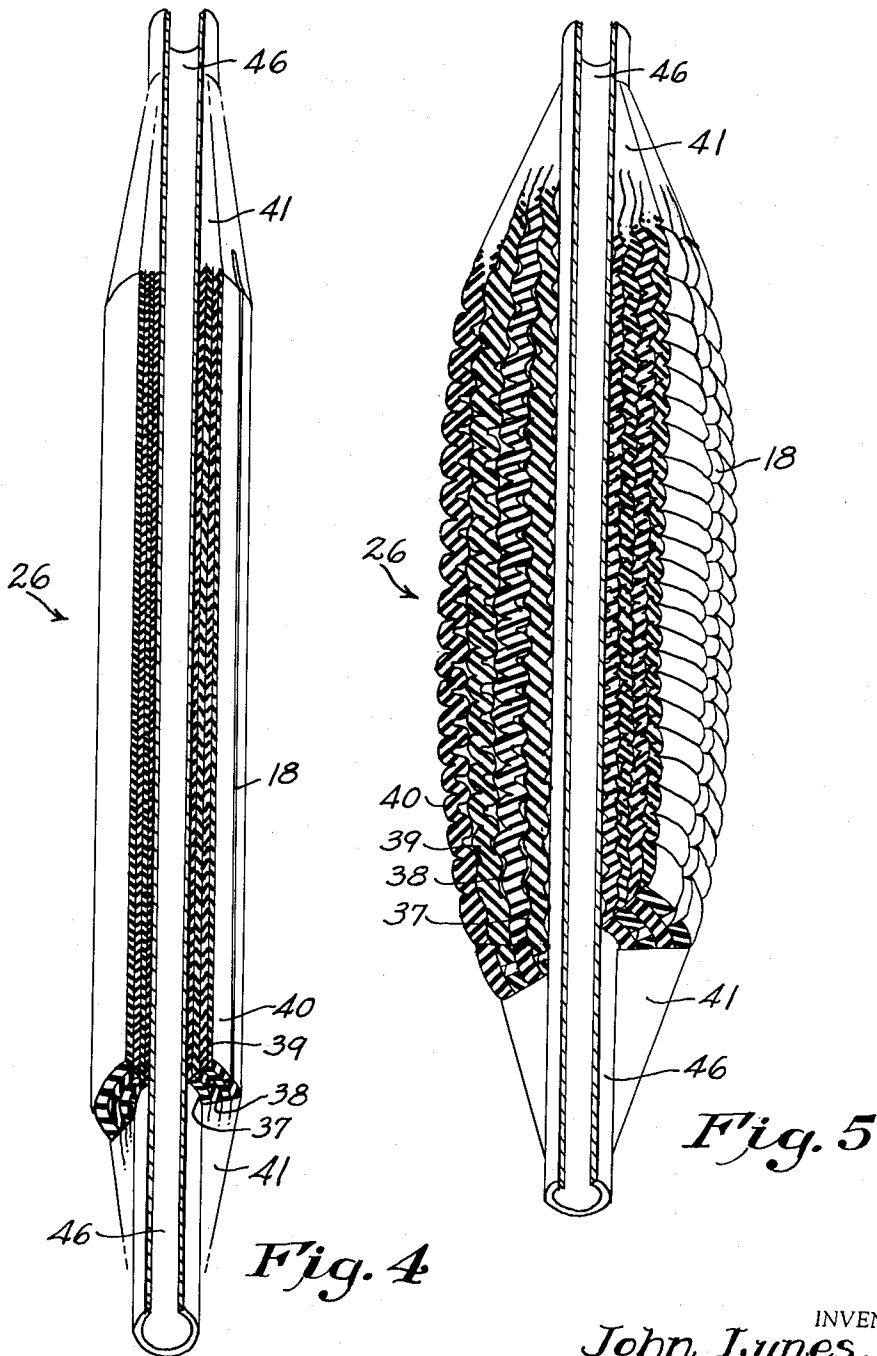
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INVENTOR:
John Lynes,

BY *Mauro & Lewis,*
ATTORNEYS

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8 Sheets-Sheet 3

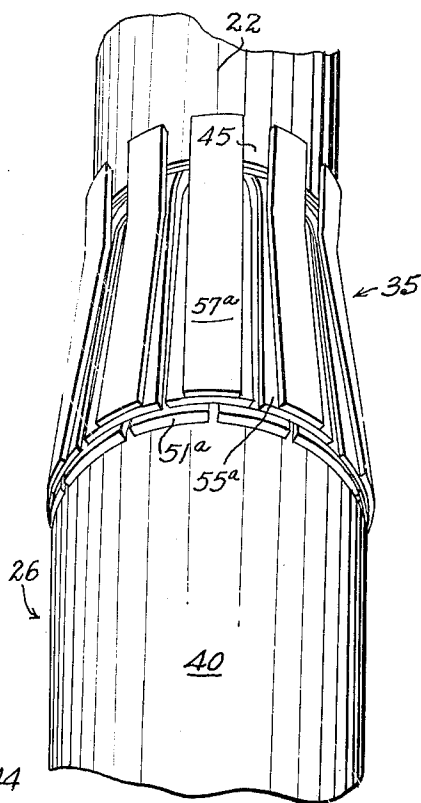
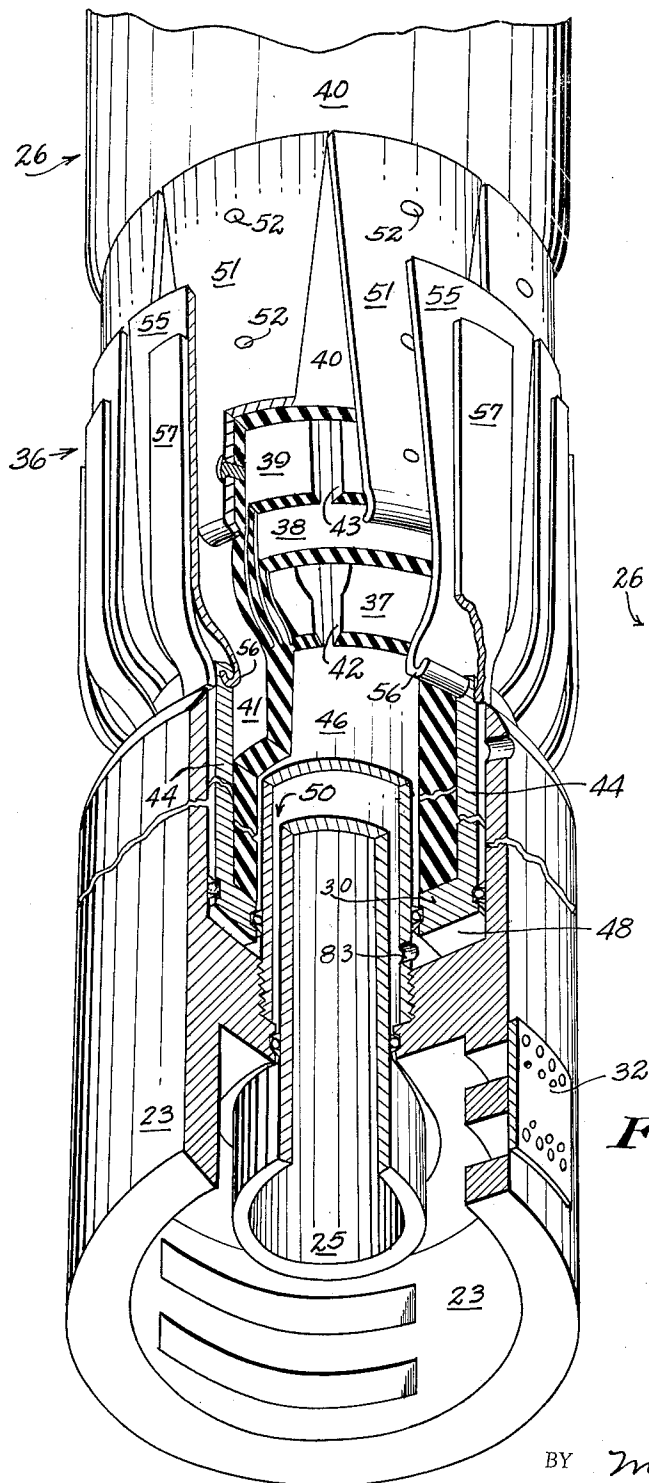


Fig. 7

Fig. 6

INVENTOR:
John Lynes,

BY *Mauro & Lewis*

ATTORNEYS

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J. LYNES
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8 Sheets-Sheet 4

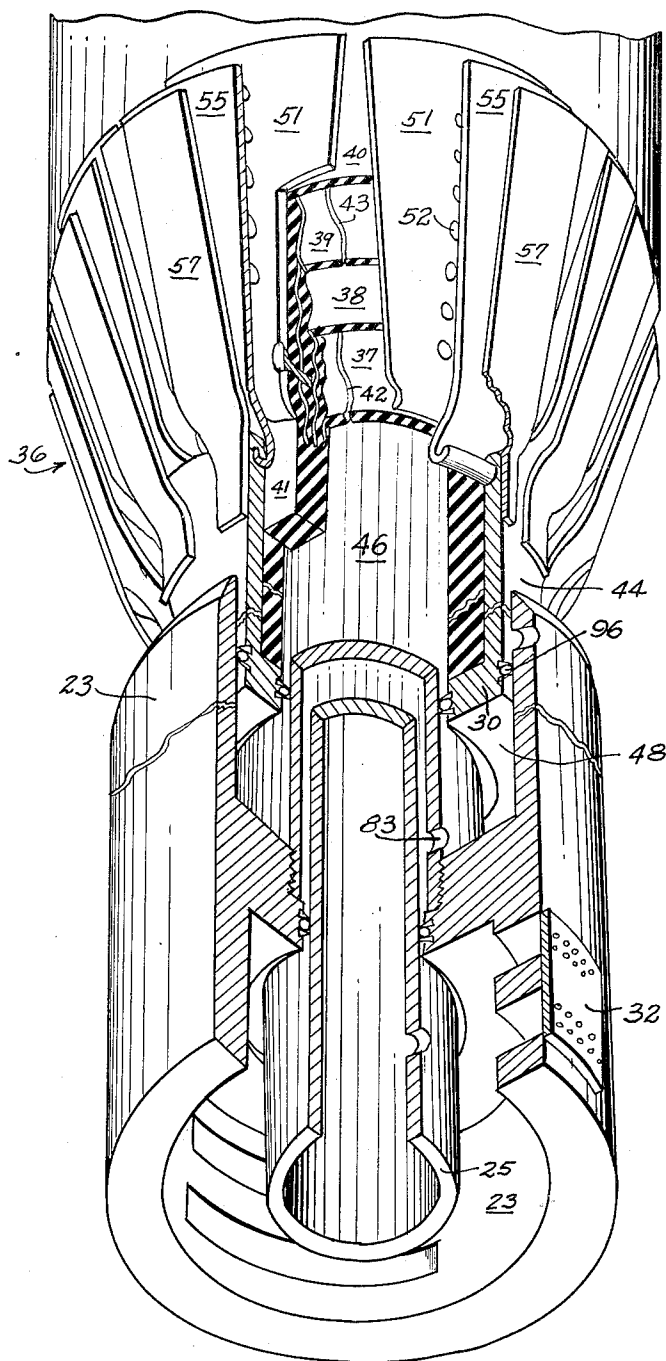


Fig. 8

INVENTOR:
John Lynes,

BY Mauro & Lewis

ATTORNEYS

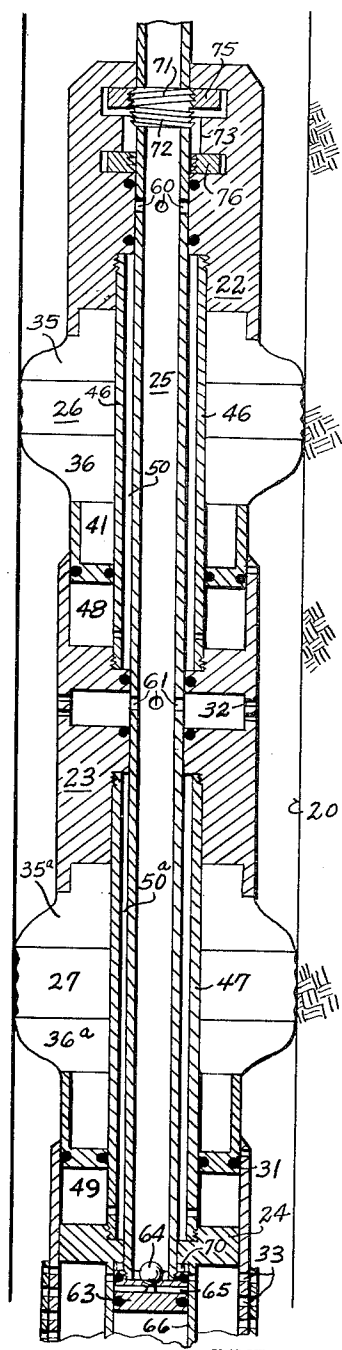
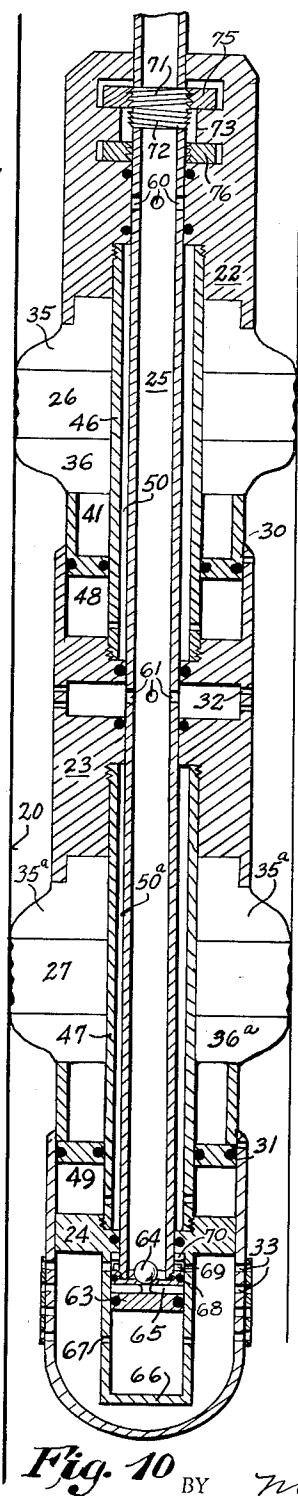
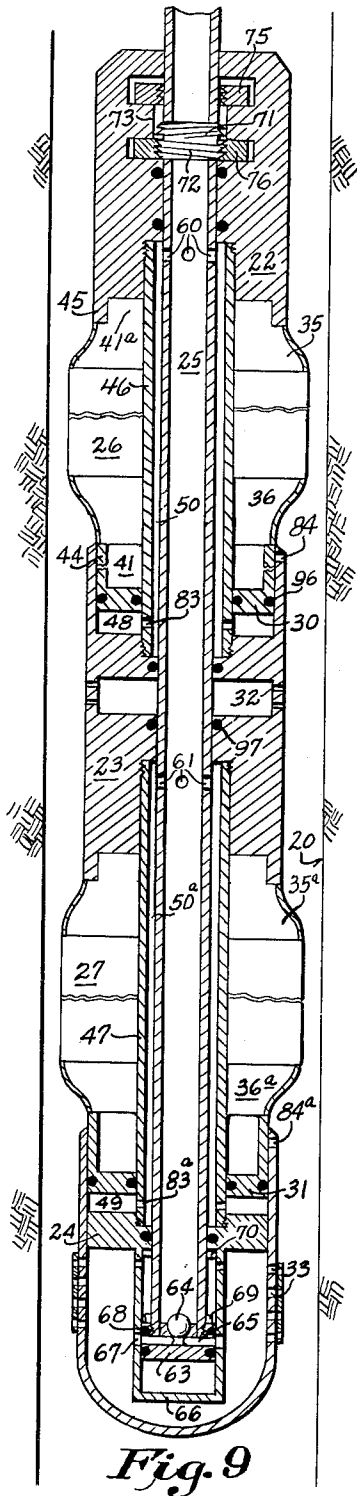
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8 Sheets-Sheet 5



INVENTOR:
John Lynes,

BY *Mauro & Lewis,*

ATTORNEYS

March 13, 1956

J. LYNES
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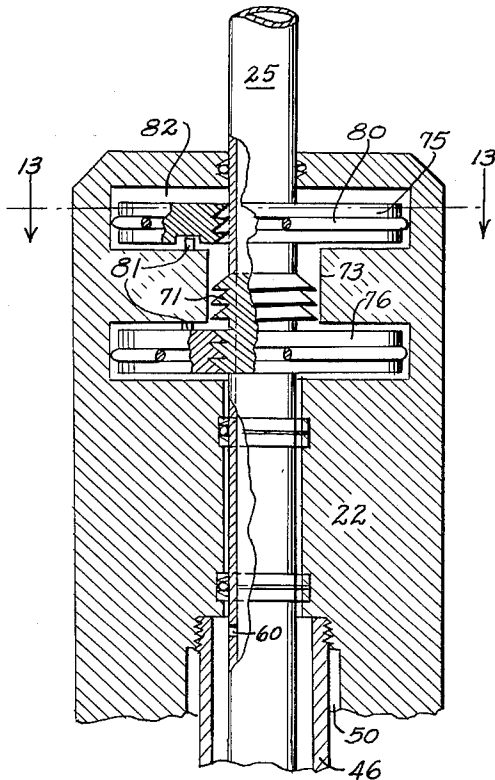


Fig. 12

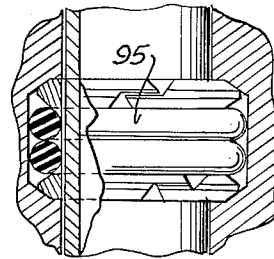


Fig. 14

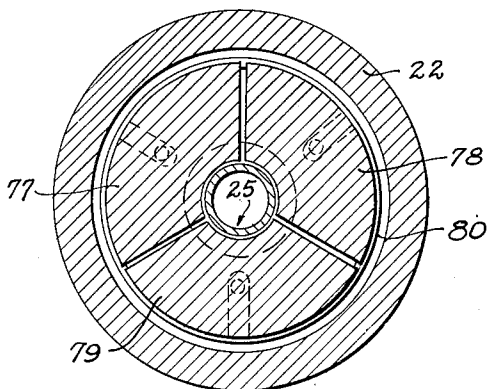


Fig. 13

INVENTOR:
John Lynes,

BY *Maurice Lewis,*
ATTORNEYS

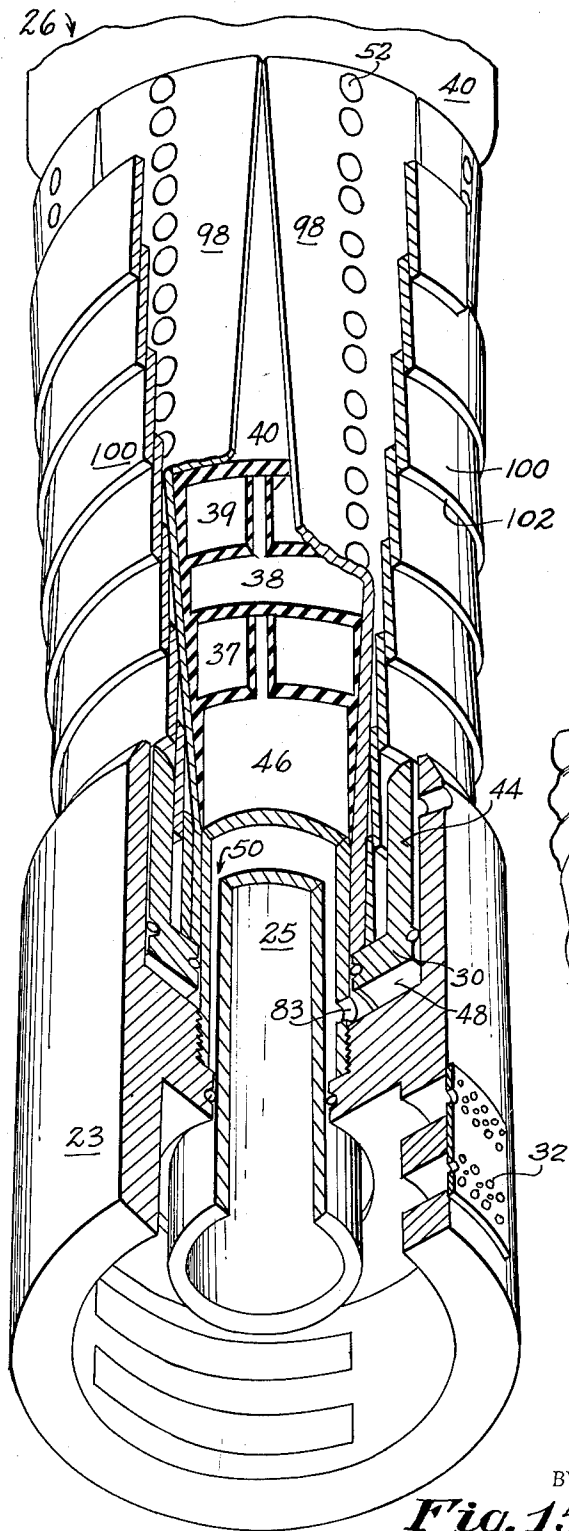
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BY
Fig. 15

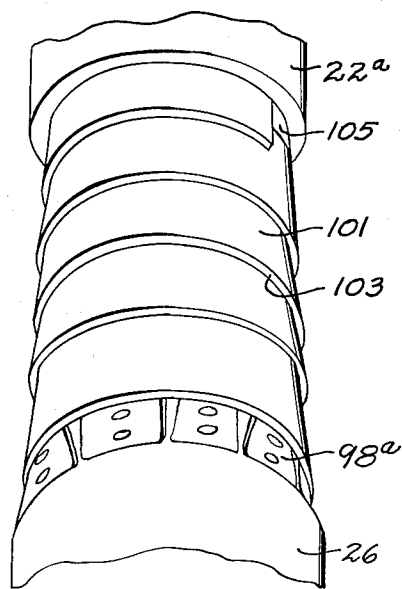


Fig. 16

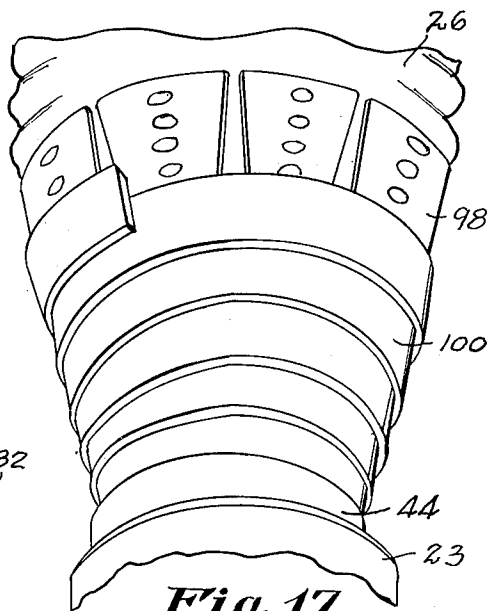


Fig. 17

INVENTOR:
John Lynes,
mauro & Lewis,
ATTORNEYS

March 13, 1956

J. LYNES
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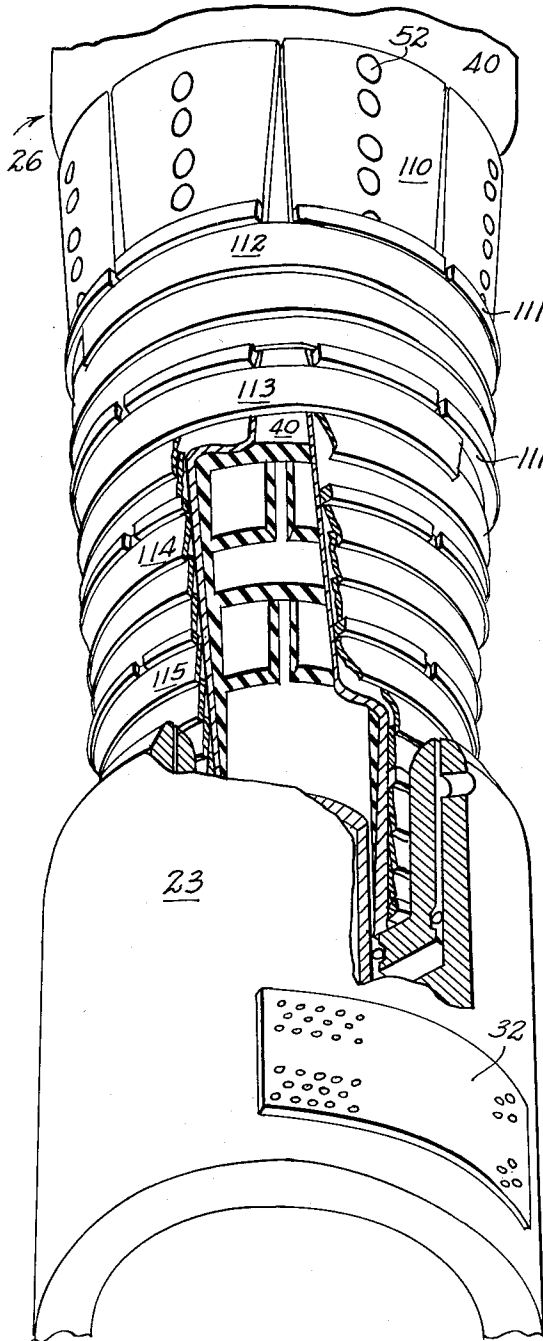


Fig. 18

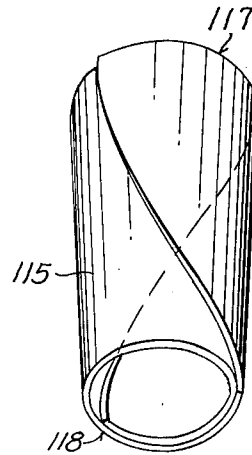


Fig. 19

INVENTOR:
John Lynes,

BY *Mauro & Lewis,*
ATTORNEYS

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2,738,013

OIL WELL TOOL

John Lynes, Albuquerque, N. Mex., assignor to Oil Recovery Corporation, Albuquerque, N. Mex., a corporation of New Mexico

Application September 5, 1952, Serial No. 307,958

13 Claims. (Cl. 166—147)

This invention relates to an oil well tool useful in the recovery of oil or gas from formations which require various treating operations in order to render them productive.

It is generally recognized that the industry is presently recovering only about 70 percent of the oil contained in oil bearing formations. The remainder is left locked in its natural state awaiting development of more scientific means and methods for its recovery.

Most hydrocarbon substances such as oil and gas are deposited in hard-type formations geologically identified as sandstone, limestone and shale. It is difficult for the oil to flow through these close-grained formations until the formations themselves have been broken up. Early methods for breaking down such formations were characterized by the use of high explosives which in most cases were found to be detrimental to the well bore as well as extremely hazardous to drilling personnel. Later methods which appear to be more satisfactory in breaking down the formations so that the content thereof may be recovered in greater quantities, are characterized by the injection of treating agents, such as acids or other chemicals.

Large numbers of wells are abandoned annually and in some cases areas that could be developed into fields of considerable size are lost, due to the lack of mechanical means for breaking down oil well formations sufficiently to allow treating agents to be forced under high pressure back into the formations so that the formations can be forced to yield their fluid content in commercial quantities. Since most chemical agents now in use must be quickly forced back into the formations in order to obtain the best results, it is apparent that, if the walls of the formation can be broken down into cracks and crevices in an operation preceding the injection of treating agents, the formations will more readily absorb such treating agents and the effect of them will be greatly enhanced.

Accordingly, the general object of this invention is to provide an oil well tool which is not only useful in sealing off oil or gas bearing formations selected for treatment but also in cracking and breaking down the formations themselves by the application of considerable force delivered by the tool.

Another object of the invention is to provide a well tool capable of operation under all conditions encountered in the drilling of wells. Such wells are frequently drilled in excess of 15,000 feet and encounter temperatures in excess of 300 degrees F., and pressures in excess of 12,000 pounds per square inch. The invention will successfully perform under such conditions.

The tool assembly comprising the invention primarily consists of one or more packer assemblies, generally used in pairs, as illustrated in the accompanying drawings, although the invention contemplates the use of one packer or a plurality thereof at different levels in the well.

An important advantage of the invention lies in the composition of each such packer, which is formed of a plurality of sleeves or layers of resilient material adapted

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to be longitudinally compressed between metallic supporting means by the action of a powerful ring-type piston or ram, hydraulically operated by water, gas, or other fluid pumped into the ram cylinder from the surface through the supporting drill pipe or tubing.

Special advantages reside in the split-sleeve composition of the packers and the bonding together of all sleeves at the respective ends.

The resilient components of each packer are uniquely designed to withstand a very high compressive action delivered by the piston and thereby to wad up and by lateral enlargement to be pressed with great force against the walls of the formation.

The split-sleeve construction makes possible a very high degree of lateral enlargement in contrast to the case where a tubular sleeve might be used. This feature makes it possible to employ resilient packer members of small diameter prior to their actuation, leaving a substantial clearance when the tool is being lowered or raised in the well bore. This is of vital importance and greatly reduces hazards of the tool sticking in the well bore and ruining the well, as has occurred frequently with many conventional packer tools now in use. For example, for a well bore of six inch diameter, the tool according to the invention may be constructed with packer members of four inch diameter in their disengaged condition, whereas many conventional packer tools have a very narrow tolerance with respect to the well bore because their construction may not permit a lateral enlargement for setting purposes greater than one-quarter inch.

The resilient packer members are capable of exerting a compression against formations of approximately 50,000 pounds per square inch, a force much greater than can be delivered through standard drill pipe or tubing. At the same time these members are remarkably rugged and of long life. In this connection, the packer construction according to the invention may be contrasted with the ordinary types of squeeze packer tools which are merely designed to provide a relatively weak seal-off of a selected formation for testing or sampling, and which are incapable of delivering the formation-cracking forces of which the invention is capable. Such conventional packer tools usually employ elastic packer elements which are hydraulically inflated by pressure delivered from the surface of the well. Such packer elements, while undergoing the requisite inflation, are made pervious to the ingress of damaging fluids, gases, and solids in the well which enter the pores of the material under great pressure. Consequently such packers are short lived. By contrast, the resilient packer members of this invention are not inflated, but forced by longitudinal compression into lateral enlargement and engagement of the formation.

Another important feature of the packer assembly lies in the various means whereby each end of the resilient members is strongly and securely held between steel collars formed of layers of steel elements designed according to the invention to prevent tearing, rupture or other damage to the resilient means, and also to withstand external pressures during treating operations, which arise from the external column of well fluid. Preferred types of this end construction and their advantages will be further described hereinafter.

Another important advantage lies in the means provided in the invention for its positive and accurate control from the surface. The invention is adapted to be lowered into the well bore at the end of a long supporting pipe such as drill pipe or tubing, generally referred to as the supporting pipe. This pipe is capable of manipulation in three ways by the operator at the surface: it may be raised or lowered, or it may be rotated in a clock-

wise direction (the direction opposite that which would cause the pipe sections to uncouple at their normally right-handed screw thread joints and be lost in the well). Utilizing these three possible motions, simple and accurate means have been incorporated in the tool which permit of its operation without danger of costly errors. Furthermore, these control means are devised so that the operator can verify the control position of the tool and correct it if a mistake has been made. The controls are also capable of repeat adjustments, eliminating any need of removing and resetting the tool at the surface.

The versatility of the operating means of the invention is provided in novel valving, shifting and locking mechanisms whereby the tool may first be lowered into the well bore with the formation-cracking packer members in closed or non-enlarged position out of contact with the bore hole walls, and with the drill pipe and tool casing open to the ingress of drilling fluid or mud present in the well bore.

In this condition the tool may be lowered to the desired location relative to the selected stratum or strata, and the piston operated packers forced to enlarge laterally against the formations, merely by pumping liquid into the tool through the drill pipe from the surface. A safety vent is provided to permit escape of fluid from the cylinder of the piston when the resilient packer members have reached optimum compression in the vertical axis, or in cases where a cavity in the well bore exists in the formation.

Next, assuming a treating operation is to be effected by injection of treating fluid into a sealed-off formation, a shifting mechanism operated by clockwise rotary motion of the drill pipe together with an upward motion of the supporting pipe will at the same time seal off the pressure-filled ram cylinders and connect the formation, through the tool, with the supporting pipe. Preparatory to injection of treating fluid, an unloading valve above the tool, opened by downward pressure on the pipe, allows the venting of the column of fluid present in the supporting pipe.

In the formation-engaging position above described, the invention, having exerted a strong cracking action upon the formations engaged by the resilient packer members, may remain as a sealing-off means for as long as desired for practical purposes. Ordinarily it will not be necessary to replenish the pressure in the ram cylinders. The invention is therefore capable of and intended for use after a treating operation, as when swabbing is performed in the drill pipe to withdraw the contents of a formation.

By further rotation of the drill pipe to operate the shifting mechanism, the expansible packer members are readily returned to disengaged position, so that the tool may be withdrawn or relocated in the same well bore. At the same time a lower valve may be opened to free the drill pipe of its contents during withdrawal.

These control means, and other objects and advantages of the invention, will be described further below in connection with the drawings, wherein:

Figure 1 is a vertical view in elevation showing the tool in position within a well but prior to actuation of the resilient packer members;

Figure 2 is a view similar to Figure 1 but showing the tool with packer members in formation-cracking position engaging the bore hole walls;

Figure 3 is a vertical sectional view, to a larger scale, of the top portion only of the embodiment of Figures 1 and 2, showing the drill pipe venting mechanism or unloading valve;

Figure 4 is an enlarged diagrammatic perspective with parts omitted and broken away, showing the composition and design of one of the resilient packer members prior to actuation;

Figure 5 is a similar view to Figure 4, illustrating diagrammatically the capability of the resilient packer to enlarge laterally when compressed longitudinally along the axis of the supporting pipe;

Figure 6 is an enlarged perspective view, with parts

broken away and parts in section, illustrating the operating piston, control valve mechanism and one embodiment of the collar construction at one end of one of the packer members, with the member in non-expanded condition;

Figure 7 is a similar view to Figure 6, on a reduced scale, showing the end construction at the other end of a packer;

Figure 8 is a view similar to Figure 6 but showing the piston extended and the packer in formation-engaging condition;

Figures 9, 10, and 11 are views similar to Figure 1, but with the vertical scale compressed, and with parts shown in section to illustrate three phases in the operation of the invention;

Figure 12 is an enlarged vertical sectional view of the upper portion of the structure shown in Figures 9-11, illustrating the action of the selective shifting mechanism;

Figure 13 is a horizontal sectional view taken on line 13-13 of Figure 12;

Figure 14 is a further enlarged fragmentary view, partly in section, illustrating the construction of one of the sealing rings used in the invention;

Figure 15 is a view similar to Figure 6, showing a modified collar construction at one end of a packer member;

Figure 16 is a view similar to Figure 7, showing the modified collar construction of Figure 15 at the opposite end of a packer;

Figure 17 is a perspective on reduced scale compared to Figure 15, showing the operation of the collar construction of Figure 15 after enlargement of the packer member;

Figure 18 is a perspective similar to Figure 15, with parts broken away, showing a further modification of packer collar construction at one end of a ram; and

Figure 19 is a perspective detail of a still further modification of packer collar construction.

The illustrated modifications of the invention relate to different means for supporting the packer members at their upper and lower ends, respectively (compare Figures 6-8 and Figures 15-19).

In Figure 1, a general view of the first embodiment is shown in elevation, as it would appear prior to operation in the borehole 20 of an oil or gas well. Figure 2 is a similar view, showing the tool after formation-breaking and sealing-off contact has been made with selected formations.

In these figures, the supporting drill pipe or tubing, coupled to the tool, is not illustrated, the upper member shown being the supporting pipe venting device or unloading valve generally designated at 21 (shown in detail in Figure 3). Coupled to venting device 21, the main part of the tool comprises upper, central and lower body members 22, 23 and 24, each being mounted in spaced relationship by means of supply pipes 46-47 (Figure 9), the tool being penetrated by the relatively movable inner communicating pipe 25. Pipe 25 forms the supporting means by connection with valve 21 (Figure 3).

For purposes of illustration, two hydraulically operated resilient packer members are shown, the upper member 26 and lower member 27.

These members 26 and 27 are thrust laterally into formation-breaking contact with the borehole 20 by means of rams or pistons 30 and 31 (Figure 2) which are pressure-actuated through pipe 25 from the surface.

A central outlet 32 between packer members 26 and 27 is provided for connection with the formation to be treated, tested or flowed, and a lower outlet 33 gives access to the borehole below the tool. Outlets 32 and 33 may be selectively connected to, or sealed off from, the inner communicating pipe 25 by means later described.

In Figures 1 and 2 are special metallic supporting means which confine the upper and lower ends of each packer member 26 and 27 are generally depicted as the upper collars 15-15A and lower collars 16-16A.

According to the invention, each packer member is designed in a form which is capable of compression along

the vertical axis of the tool to an extraordinary degree, with the result that the resilient elements of the member wad together in an accordion-like fashion with consequent lateral enlargement causing the packer to make contact with the borehole walls and delivering a formation-breaking compression thereto. For example, a resilient packer member constructed according to the invention may be of four inch diameter and fourteen feet in vertical length: this length may be reduced to twenty inches when vertically compressed, the resulting expanded diameter being limited by the actual borehole diameter.

Referring now to Figures 4-8, it will be seen that packer 26 is composed of a plurality of overlapping plies or sleeves of resilient material, four being illustrated at 37, 38, 39 and 40. The upper and lower ends 41 of these plies are bonded together, as by vulcanizing. Preferably between the bonded ends 41, each ply is provided with a longitudinal open or split seam, the seams being arranged on alternative sides per layer. Shown in Figures 6 and 8 are the seam 42 of ply 37 and seam 43 of ply 39, it being understood that plies 38 and 40 possess similar open seams, not shown, adjacent the rear of the tool. The purpose of these open or split seams is to enhance the ability of the resilient packer member to wad or bunch together and enlarge laterally. Locating the seams to avoid overlapping will avoid weakening the packer member at any particular point in its periphery and retard the entry of external matter into the plies 37-40. Obviously the open seams may be disposed peripherally at selected points consistent with this object.

In Figures 4 and 5 the resilient packer members 26 are shown schematically as they appear when in collapsed or non-operative, and enlarged positions, respectively. Figure 5 is intended to illustrate the approximate effect upon the packer plies with their split sleeve construction, when the piston delivers a powerful compressive thrust along the axis of pipe 46. In this view the outer sleeve 40 has a seam 18 which has opened to permit substantial lateral enlargement of the packer, this being illustrative of the action of the split seams on the other inner plies or sleeves. Lower packer members 27 are similar to packers 26 in all respects.

The material composing the packer plies 37-40 may be rubber or preferably a synthetic of the types especially adapted to resist the temperatures and fluids encountered in oil wells. In fabricating the plies, however, it is desirable that the central portions be relatively resilient or elastic and that the bonded end portions 41 and the portions beneath the collars 35-36 be of high durometer or relatively inelastic.

As seen in Figures 6-11, the packer 26 is contained at its lower end 41 in shoulder 44 of the ring piston 30. The upper end 41A (Figure 9) is similarly contained in a shoulder 45 of upper body member 22. Packer 27 (Figure 9) is likewise supported between piston 31 and central body member 23. Packer 26 encloses supply pipe 46, the latter being socketed in body members 22 and 23 in turn enclosing the inner communicating pipe 25 to provide the supply channel 50. A similar design for packer 27 consists of supply pipe 47 secured to body members 23 and 24, and channel 50A. A cylinder 48 is formed in the upper portion of body member 23 and contains the ram or piston 30, whereas piston 31 operates in cylinder 49 formed in the upper portion of body member 24. Cylinder 48 is supplied with fluid under pressure via pipes 25 and 46; cylinder 49 is supplied via pipes 25 and 47, by means of ports to be described.

When piston 30 is actuated to provide an elongated stroke resulting in longitudinal compression of the packer 26, special collar members are provided according to the invention to confine the flexible plies 37-40.

Four species of such collar members are shown. In the embodiment common to Figures 6-11, the collar 36 consists first of an inner layer of metal bearing plates 51 disposed peripherally around the outer sleeve 40, and secured

thereto by vulcanization and by rivets 52. Plates 51 are suitably tapered to permit lateral expansion of the ply 40 into the shape shown in Figure 8.

Plates 51 serve the dual purpose of strengthening the lower end of ram 26 and additionally serve as a seating or bearing means for the intermediate plate layer of the collar 36 consisting of the hinged plates 55. Plates 55 are likewise suitably tapered and securely linked at 56 to the shoulder 44 of piston 30.

The outer spring plates 57 of collar 36 are attached as by welding to the outer periphery of shoulder 44 and are adapted to press inwardly on the hinged plates 55.

The collar assemblage of plates 51, 55 and 57 is specially designed to confine the packer 26 adjacent its collar 36. When the packer 26 is actuated, as shown in Figure 8, these plates will fan out into contact with the borehole. Desirable slippage is provided between plates 51 and 55, these being secured to the resilient ply 40 and the piston, respectively. This slippage allows for lateral movement of the packer and natural lubrication is provided by the fluid in the borehole. At the same time the overlapping arrangement of the plate layers inhibits any substantial permeation of drilling fluid or other substances into the collar 36.

A similar collar construction to that of Figures 6 and 8 is provided for the upper collars 35 of packer 26 and 35A of packer 27. Figure 7 on a reduced scale shows this similar collar construction for the upper collar 35. The inner collar plates 51A are secured to ply 40 as above described for plates 51; plates 55A and 57A are similar to plates 55 and 57, excepting for their attachment to the lower shoulder 45 of the body member 22. The elements of collar 35A, not shown in detail, are similar to collar 35.

The operation of the tool will now be described with particular reference to Figures 3 and 9-14, inclusive. In Figures 9-11, it will be seen that body members 22-23 are held in rigid relationship by means of supply pipe 46 and that body members 23-24 are similarly supported by lower supply pipe 47. The inner communicating pipe 25 is movable relative to these elements, vertically and axially, and is the tool supporting means through a threaded connection to the drill pipe venting device (Figure 3).

Pipe 25 contains a series of lateral ports. Fluid supply ports 60 may be connected with or closed from channel 50 formed between the outer wall of pipe 25 and the surrounding supply pipe 46. Similarly, central ports 61 either make connection with supply channel 50A formed between supply pipe 47 and pipe 25 (Figure 9) or it may be opened into connection with the central outlet 32 (Figure 10).

Threaded at 68 to the lower end of pipe 25 and contained in the lower outlet chamber 33 of lower body member 24 is a valve fitting 63 containing ball valve 64 which rests in a seat leading to valve ports 65. Valve fitting 63 is slidable in housing 66 formed on member 24. Housing 66 contains ports 67 which may be connected with valve ports 65.

The screw-thread connection 68 joining valve fitting 63 to pipe 25 is left-handed, and keys 69 may be engaged with projections 70 on the body 24 so that the fitting 63 may be disconnected during one operating step to be described.

Communicating pipe 25 is shiftable to two principal positions for operating purposes with respect to the tool in which it is contained. The control means consists of a pair of threaded screw collars 71 and 72 secured on pipe 25 and movable in a chamber 73 in upper body member 22. Figures 12 and 13 show this construction in detail. Lower collar 72 has a left-hand thread and upper collar 71 has a right-hand thread.

Housed in body 22 for cooperation with collars 71, 72 are a pair of threaded snap rings 75 and 76. Upper snap ring 75 carries an inner right-hand thread and lower ring 76 carries a left-hand thread.

Each snap ring (Figure 13) may be composed of three segments 77, 78, 79 contained in a peripheral spring 80 and held against rotation in body 22 by keys 81.

When the upper screw collar 71 engages pipe 25 in upper snap ring 75 a clearance provided in chamber 82 (Figure 12) permits a lifting of pipe 25 to engage keys 69 of the lower valve fitting 63 with projections 70 carried by lower housing 24 (Figure 11) in order to remove fitting 63 from pipe 25.

The above control means will now be described with respect to a typical cycle of operations. In Figure 9 the tool is in position in a borehole 20 for actuation of the packers 26—27. While being lowered to this position, it will be seen that pipe 25 has been open to the inward flow of well fluid through lower outlet 33, ports 65 and 67 and ball valve 64; the latter, however, will close upon any pressure increase delivered into pipe 25.

In this condition the tool is ready for actuation of the packers 26—27, which is accomplished by pumping fluid under pressure into pipe 25. This fluid will pass through ports 60—61 into channels 50—50A, thence through ports 83—83A into cylinders 48—49, actuating pistons 30—31. Near the end of the piston stroke, safety vent ports 84 and 84A are provided in the walls of cylinders 48 and 49 to prevent excessive piston movement.

Packers 26 and 27 are thus forced against the borehole walls while being confined between the collars 35—35A and 36—36A.

While pressure is being maintained the tool is next shifted to its locked-in position by rotating the supporting pipe clockwise, causing collar 72 to unscrew from lower snap ring 76. A slight upward pull on the pipe will then snap upper collar 71 into engagement with upper snap ring 75, bringing the tool into the condition shown in Figure 10.

As seen in Figure 10, the upper position of pipe 25 within the tool causes a disconnection between ports 60—61 and supply pipes 46—47, with the result that the fluid pressure in cylinders 48—49 will remain sealed off for as long as desired. Also in the Figure 10 position it will be noted that ports 61 have been lifted to communicate into central outlet 32. At the same time the lower valve fitting 63 has been lifted in housing 66 to disconnect ports 65 and 67, preventing egress of fluid from pipe 25.

Consequently in the Figure 10 position, the tool is ready for treating or testing operations, except that it is first desirable to vent the column of drilling mud from the pipe into the borehole. The packers being now in locked position, this is accomplished by downward movement of the supporting pipe to actuate the venting device 21 shown in detail in Figure 3, followed by pumping.

The venting device 21 comprises an outer pipe 85 having a narrow neck 86 with a lower shoulder forming a seat for coil spring 87. An inner pipe 89 is slidable in pipe 85 and is confined therein by the shoulders 90. Shoulders 90 carry keys 17 slidable in splines 16 formed in pipe 85, to prevent relative rotation between pipes 85 and 89. Pipe 89 terminates in a nipple 91 which forms the lower seat for spring 89.

Ports 92 in pipe 89 and ports 93 in pipe 85 are relatively arranged so that they will connect when downward pressure is exerted to overcome the action of spring 87. With ports 92—93 in register the supporting pipe above pipe 85 may be pumped clear of fluid not intended for entry into the formations through outlet 32. The pumping out of the supporting pipe may take place by pumping a treating fluid through the pipe and closing the device 21 at a time when, from calculating the volume of the supporting pipe, it is known that the treating fluid has reached the ports 92—93. Consequently, in a treating operation the supporting pipe can be evacuated of drilling fluid, so that the remainder which is forced into the formation through outlet 32 is merely the small residue contained in the upper half of pipe 25. Obviously, the purpose of device 21 is

to avoid pumping any undesirable amount of drilling fluid into the formation in advance of the treating fluid.

In the Figure 10 position the tool has delivered a forceful formation-cracking action to the adjacent formations, and treating fluids may be injected through the ports 61 and outlet 32. After treating, recovery from the formations may likewise be effected as by swabbing in the supporting pipe to remove the column of fluid therein and allow the fluid from the formations to flow into the supporting pipe through outlet 32, ports 61 and pipe 25.

As shown in Figure 11, access through the tool to the borehole beneath is effected by removal of the valve fitting 63. This removal is a desirable preliminary to withdrawal of the tool from the borehole, to avoid bringing the contents of the supporting pipe to the surface. To remove valve fitting 63 the pipe 25 is slightly raised and rotated as seen in Figure 11, the upper snap ring 75 moving to the top of chamber 82 (Figure 12) and causing keys 69 (Figure 10) to engage projections 70 (Figure 11) to unscrew fitting 63. Figure 11 shows fitting 63 in position to be unscrewed. When unscrewed, fitting 63 will drop into housing 66, leaving ports 67 open into pipe 25.

To remove the tool from the borehole, or to relocate it, a return to the Figure 9 position is accomplished by again rotating pipe 25 in the clockwise direction. The threaded connection between upper snap ring 75 and upper collar 71 will disengage and lower collar 72 will snap into engagement with lower snap ring 76, the weight of the supporting pipe assisting this downward shift. The fluid pressure in cylinders 48—49 will then be released into pipe 25 and packers 26—27 will disengage the borehole.

As will be seen in Figures 3—12, sealing-off means are shown at various positions necessary to perfect operation. A detail of a known type of sealing ring 95 is shown in Figure 14, for use at points such as at 96, 97 (Figure 9).

Figures 15—17 show a modified form of construction for the packer collars. In these views upper packer 26 is shown prior to actuation (Figure 15) and after the piston has operated to cause the resilient packer member to expand laterally (Figure 17). The resilient split-sleeve ply construction is the same as previously described.

Ply 40 likewise carries similar inner collar plates 98 vulcanized and riveted at 52. Plates 98, however, are elongated compared to plates 51 (Figure 6) and extend into abutment with piston 30 interiorly of shoulder 44. In substitution for the hinged plates 55 and outer spring plates 57 of the Figures 6—8 modification, a pair of coil springs are provided as the retaining means of each collar. Spring 100 is shown in Figure 15 at the lower piston end of the packer 26 and is preferably coiled spirally in the manner shown so that the edges 102 of spring 100 face downwardly with respect to the borehole, to prevent any possible engagement with the borehole which might prevent withdrawal of the tool from the well. Spring 101 is shown in Figure 16 at the upper end of the packer, wrapped in the manner shown, with edges 103 also facing downwardly.

The upper end of spring 101 is secured in a shoulder recess 105 formed in the end of upper body member 22A.

It will be understood that spring 100 and 101 are pre-loaded or properly tensioned so that they exert a firm grip on the underlying plates 98 and 98A, even while in the non-operating position shown in Figure 15, so that the ends of the springs nearest the flexible packer member require no added securing means. Likewise the spring ends held in the shoulder 44 and the similar recess 105 formed in member 22A are free to move axially of the tool.

Consequently as pressure is applied to the piston 30 and the resilient material of packer 26 begins to enlarge laterally, as shown in Figure 17, spring 100 is free to uncoil or unwind until its outer layers or wrappings have expanded into contact with the borehole, the resilient plies of packer 26 thus being securely confined. This action is assisted by the plates 98 which underlie spring

100 since the former, lubricated by borehole fluid, provide a hard bearing surface over which the springs may uncoil as described. While this action is taking place, plates 98 are also being forced outwardly in the manner described for plates 51 (Figure 8), thus maintaining contact with the inner sides of the spring 100. Obviously the enlargement of upper spring 101 takes place in a similar manner to that described for the lower spring 100 shown in Figure 17.

To obtain springs of suitable characteristics for the above purposes a long flat bar of steel may be rolled into the desired shape and size, then heat treated to provide a spring of great tensile strength.

Figure 18 shows a further modified form of collar, in a view similar to Figure 15, some details being omitted. The Figure 18 collar will be described by comparison to that of Figures 15-18, to avoid unnecessary repetition. In Figure 18, the collar plates 110 are similar to plates 98, except that they are provided with spaced shoulders 111. In the spaces between shoulders 111 are a plurality of coiled springs 112, 113, 114 and 115. Each of these springs is pretensioned to exert a compressive action upon plates 110 and to uncoil individually upon enlargement on the packer 26 in a manner similar to the springs 100-101 of Figures 15-16. In the provision of a plurality of springs as shown, each spring is separately mounted and can act independently. Breakage of one or more springs will not affect the operation and effect of the remainder. Obviously, the opposite or upper end of packer 26 may be provided with a similar collar such as shown in Figure 18.

Figure 19 shows a detail of a further modified embodiment of packer collar, the spring element only being illustrated in the form of spring sleeve 115, which may obviously be substituted for springs 100-101 of the Figures 15-18 modification, other parts remaining the same. Spring sleeve 115 is formed from a trapezoidal shaped blank in the form of a cone, and suitably heat treated to provide resilience. The larger end 117 thus contains more overlapping material and is the collar end for use adjacent the resilient packer member. Smaller end 118 may be mounted in the piston shoulder or shoulder formed in the opposite body member. The uncoiling action of sleeve 115 is also similar to that described for spring 100.

I claim:

1. In a well tool of the character described, a body adapted to be attached to the lower end of a string of pipe or the like in a well, an elongated compressible member carried by said body, actuating means also carried by said body operable against said compressible member to longitudinally compress and laterally expand said member, and collar members surrounding the end portions of said compressible member, said collar members each being composed of an inner ring of bearing plates secured to the end portions of said compressible member, and outer ring means tensioned to compress said inner ring of bearing plates and located substantially to overlap the spaces formed between said inner ring of plates when said inner ring is expanded by said compressible member.

2. In a well tool of the character described, a body adapted to be attached to the lower end of a string of pipe or the like in a well, an elongated compressible member carried by said body, actuating means also carried by said body operable against said resilient member to longitudinally compress and laterally expand said member, and collar members surrounding the end portions of said compressible member, said collar members each being composed of an inner ring of bearing plates secured to the end portions of said compressible member, and a coil spring tensioned to compress said inner ring of plates and located substantially to overlap the spaces formed between said inner ring of plates when said inner ring is expanded by said compressible member.

3. The tool according to claim 2, wherein the coil spring is in the form of a conical sleeve.

4. In a well tool of the character described, a body adapted to be attached to the lower end of a string of pipe or the like in a well, an elongated compressible member carried by said body, actuating means also carried by said body operable against said compressible member to longitudinally compress and laterally expand said member, and collar members surrounding the end portions of said compressible member, said collar members each being composed of an inner ring of bearing plates secured to the end portions of said compressible member, and a plurality of coil springs tensioned to compress said inner ring of plates and disposed in sequence thereon substantially to overlap the spaces formed between said inner ring of plates when said inner ring is expanded by said compressible member.

5. In a well tool of the character described, a body adapted to be attached to the lower end of a string of drill pipe or the like in a well, an elongated compressible member, means for supporting the end portions of said compressible member on said body, actuating means operable against said supporting means to longitudinally compress and laterally expand said compressible member, and collar members surrounding the end portions of said compressible members, said collar members each being composed of an inner ring of bearing plates secured to said end portions, an intermediate ring of plates overlapping said inner ring of bearing plates and pivoted to said supporting means, and an outer ring of spring plates secured to said supporting means and overlapping said intermediate ring.

6. In a well tool of the character described, a body adapted to be attached to the lower end of a string of pipe or the like in a well, an elongated compressible member carried by said body, actuating means also carried by said body operable against said compressible member to longitudinally compress and laterally expand said member, said member being composed of overlapping plies of compressible material having open seams formed substantially lengthwise therein, the seams in adjacent plies of material being located to avoid overlapping, and collar members surrounding the end portions of said compressible member, said collar members each being composed of an inner ring of bearing plates secured to the end portions of said compressible member, and outer ring means spring-tensioned against said inner ring of bearing plates and located substantially to overlap the spaces formed between said inner ring of plates when said inner ring is expanded by said compressible member.

7. In a well tool of the character described, a body adapted to be lowered into a well, an internal pipe selectively movable relative to said body and supporting said body by connection to the lower end of a string of supporting pipe, an elongated compressible member carried on said body, fluid operated actuating means operable to force said compressible member into lateral expansion against the walls of the well, a port in said body connected to said actuating means, port means in said internal pipe connected selectively to said body port or with means leading to a formation in the well by spaced movement of said internal pipe into one of two selected positions relative to said body, and latching members securing said pipe and body in either of said positions, said latching members being operable exclusively by manipulation of said string of supporting pipe.

8. The well tool according to claim 7, wherein the latching members consist of a screw collar carried on the internal pipe having two segments of opposite threading, and a pair of snap rings carried by said body member each having opposite threading for selective engagement or disengagement with said screw collar by rotation and vertical movement of said supporting pipe.

9. A well tool of the type described comprising a body having an internal pipe selectively movable relative to said body and supporting said body in a well by connection to the lower end of a string of supporting pipe, a pair of spaced elongated compressible members each secured

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at one end to said body and at their opposite ends being connected to pressure-operated pistons operable in cylinders contained in said body, the stroke of said pistons acting to compress said compressible members longitudinally to cause lateral enlargement thereof into contact with the walls of the well, metallic bearing members secured peripherally around the end portions of said compressible members, spring-tensioned collar means confining said end portions and overlapping said bearing members, port means in the internal pipe selectively connecting said supporting pipe with the cylinders and with means leading to the well formation between said compressible members, and a shifting mechanism locking said internal pipe in either of two selected positions in said body for opening and closing the port means selectively to the cylinders or to the well formation.

10. In a well tool of the character described, a body adapted to be attached to the lower end of a string of pipe or the like into a well, an elongated compressible member carried by said body, actuating means also being carried by said body operable against said compressible member to longitudinally compress and laterally expand said member, said member being composed of tubular overlapping plies of compressible material, said plies being separate from one another and capable of lateral folding, except at the ends thereof which are secured together, and open seams formed substantially lengthwise in adjacent plies of said compressible material, the seams in said adjacent plies being located to avoid substantial overlapping.

11. In a well tool of the character described, a body adapted to be attached to the lower end of a string of pipe or the like in a well, an elongated compressible member carried by said body, actuating means also carried by said body operable against said compressible member to longitudinally compress and laterally expand said member, and collar members surrounding the end portions of said com-

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pressible member, said collar members being composed of inner segmental ring means substantially enclosing said end portions when said compressible member is unactuated, the segments of said ring means tending to separate upon enlargement of said end portions, and outer ring means substantially enclosing said inner ring means, said outer rings being capable of expansion during the enlargement of said end portions, while exerting resistance to said enlargement, thereby confining said end portions while permitting a limited expansion thereof.

12. The tool according to claim 11, wherein the actuating means includes a cylinder mounted in said body, a piston in said cylinder operatively connected to one end of said compressible member, and means for delivering fluid pressure to said cylinder.

13. The tool according to claim 11, wherein the actuating means includes a cylinder mounted in said body, a piston in said cylinder operatively connected to one end of said compressible member, means for delivering fluid pressure to said cylinder including a port therein, and means for selectively opening and closing said port.

References Cited in the file of this patent

UNITED STATES PATENTS

1,513,228	Crotto	Oct. 28, 1924
1,549,168	Townsend	Aug. 11, 1925
1,831,724	Stokes	Nov. 10, 1931
2,082,113	Layne et al.	June 1, 1937
2,159,640	Strom	May 23, 1939
2,196,658	Burt	Apr. 9, 1940
2,227,731	Lynes	Jan. 7, 1941
2,449,514	Scoville	Sept. 14, 1948
2,516,580	Lynes	July 25, 1950
2,516,581	Lynes et al.	July 25, 1950
2,611,437	Lynes	Sept. 23, 1952
2,637,400	Brown et al.	May 5, 1953