March 13, 1956 J. LYNES 2,738,018

OIL WELL TREATING AND PRODUCTION TOOL

Filed March 12, 1953 5 Sheets-Sheet 1

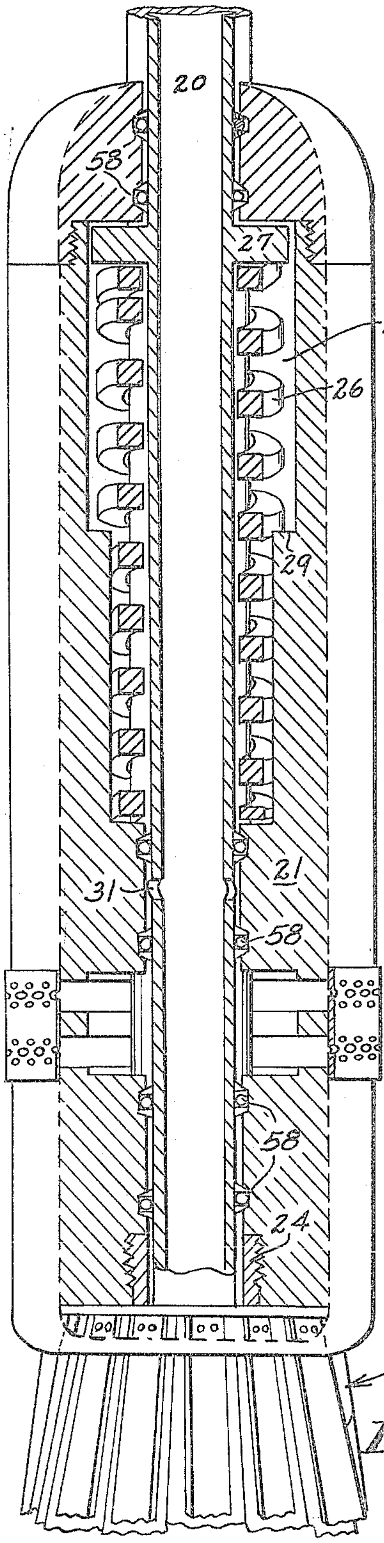

Fig. 1

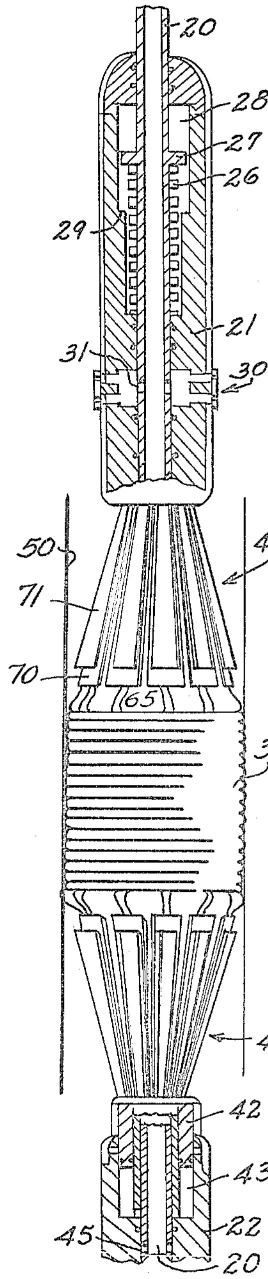

Fig. 6

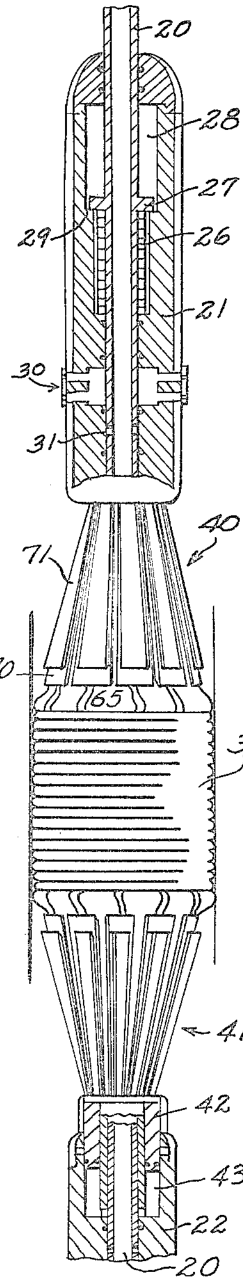

Fig. 8

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OIL WELL TREATING AND PRODUCTION TOOL

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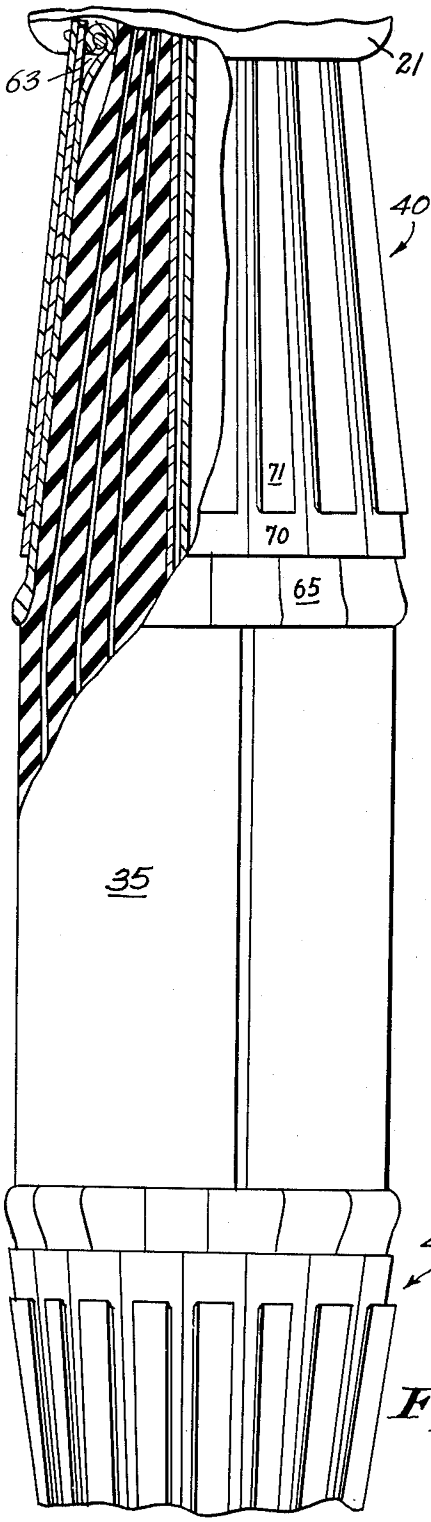

Fig. 2

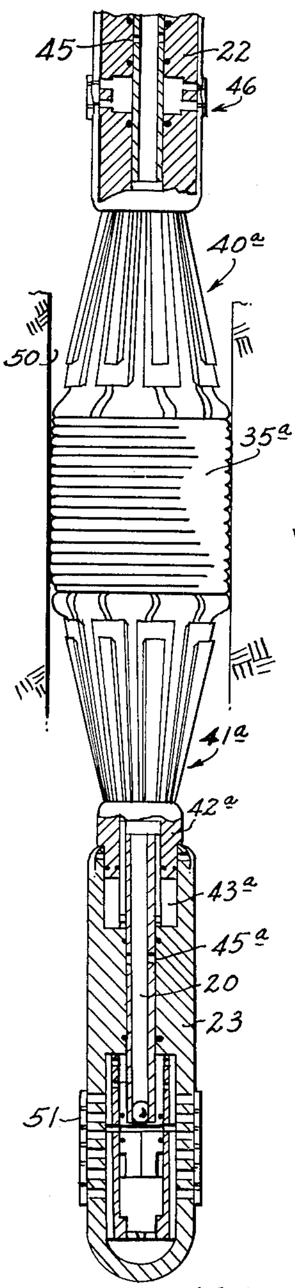

Fig. 7

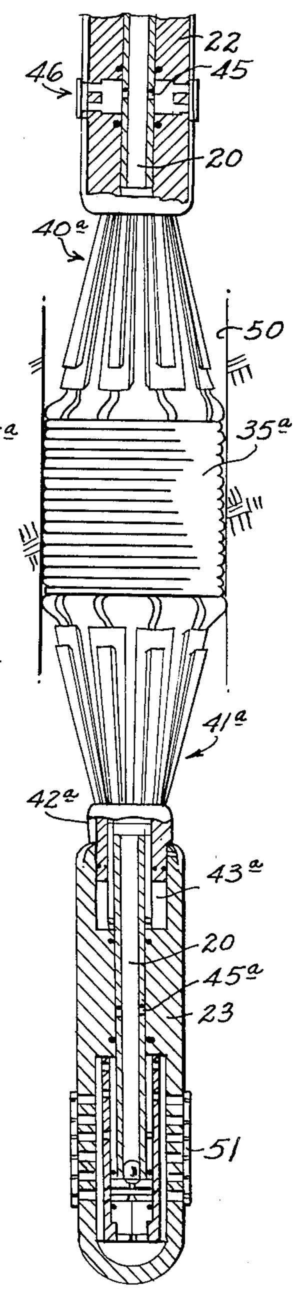

Fig. 9

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OIL WELL TREATING AND PRODUCTION TOOL

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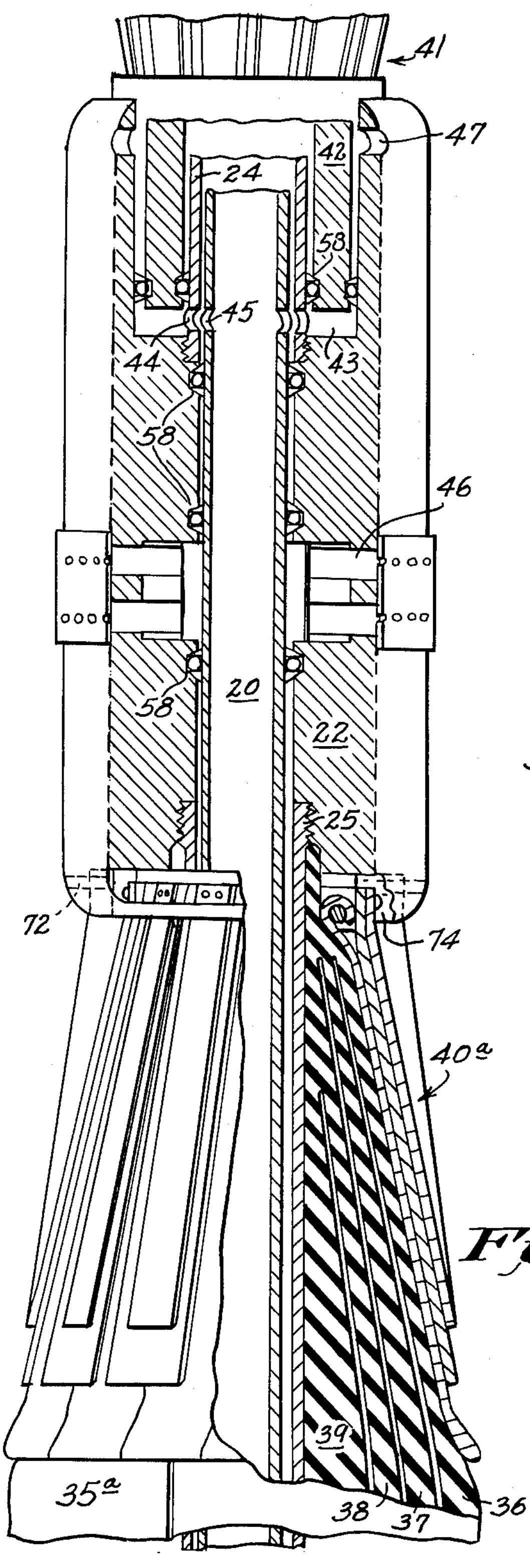

Fig. 3

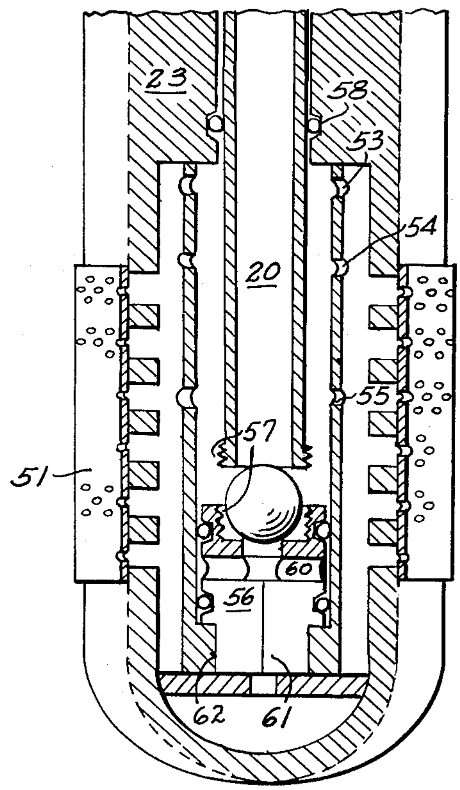

Fig. 10

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OIL WELL TREATING AND PRODUCTION TOOL

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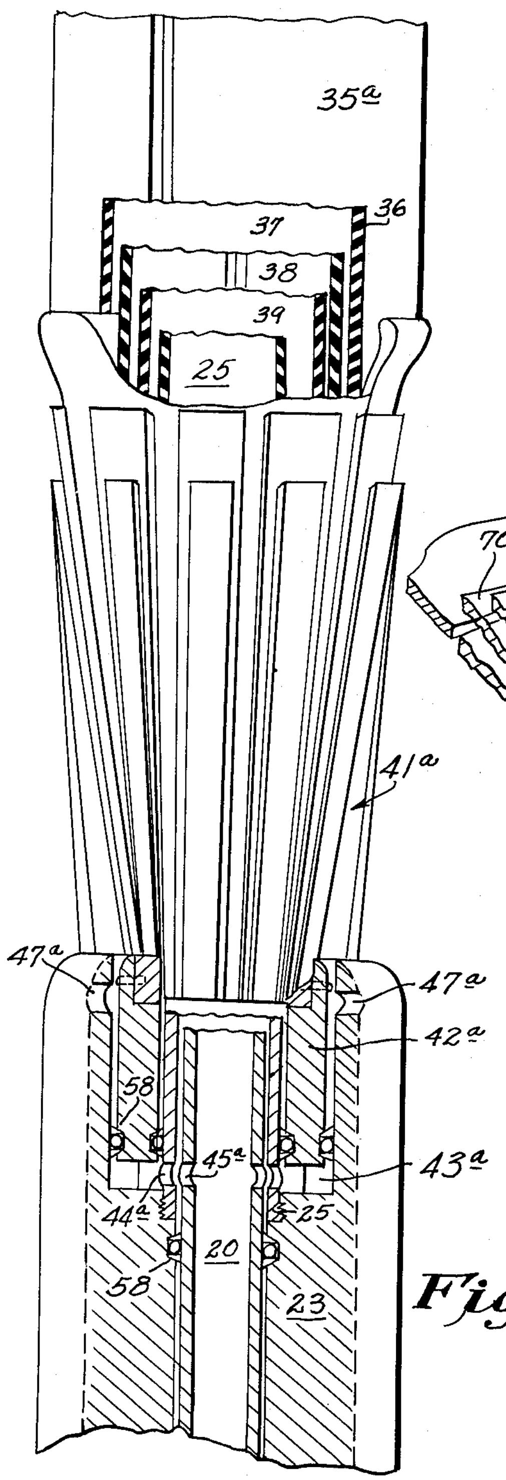

Fig. 4

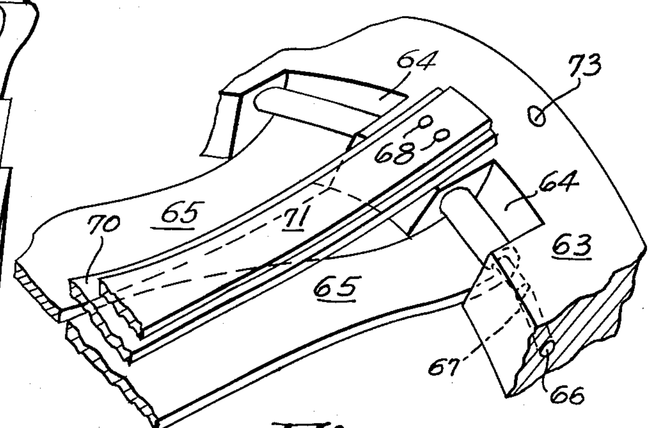

Fig. 11

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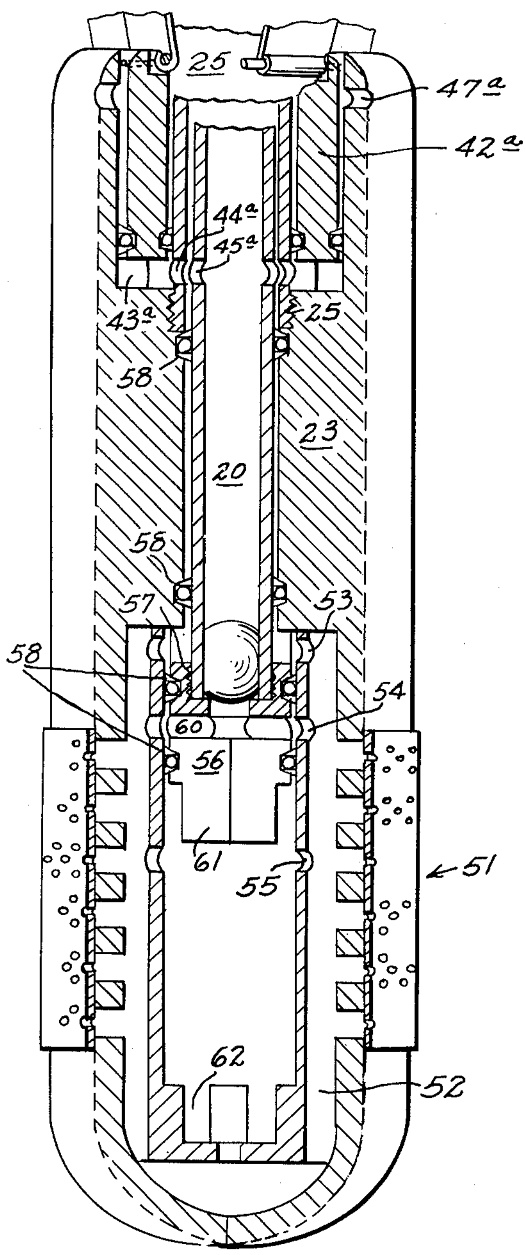

Fig. 5

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OIL WELL TREATING AND PRODUCTION TOOL

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Application March 12, 1953, Serial No. 341,896

7 Claims. (Cl. 166—204)

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

The present specification covers a tool which, generally speaking, has the same objectives and advantages as the "Oil Well Tool," the subject of my prior copending application Serial No. 307,958, filed September 5, 1952, whereof this application is a continuation-in-part. This invention therefore provides a tool useful in sealing off a formation selected for treatment and production, in delivering adjacent the formation a compressive thrust capable of cracking or breaking down the walls of the well to form channels for the flow of fluid or gas, and in forming a fluid line connection between the selected formation and the well head for treating and production purposes.

The tool assembly comprising the invention consists of one or more piston-operated hydraulic packers, usually used in pairs and so illustrated in the accompanying drawings. The invention is characterized by a tool of very rugged design due to several novel features, capable of repeated uses under deep well conditions of excessive pressures and temperatures. The invention is also characterized by its simplicity of operation from the surface, due to novel control means capable of easy and sure manipulation.

By comparison to the tool of my Serial No. 307,958, the present tool presents modified control means throughout the tool, and modified collar means whereby the resilient packer members are confined securely while powerful force is exerted upon them to bring them by hydraulic rams or pistons into formation-fracturing contact with the selected formation in the well.

Other and further objects and advantages will be described below. In the drawings:

Figs. 1–5 are elevations, with parts broken away, showing the tool in sequential segments from top to bottom, the tool in these views being in condition for lowering into a well and ready for actuation of the resilient ram members;

Figs. 6–7 are similar views on a reduced scale, showing the tool with packer members in formation-engaging and cracking position, with controls in position for venting the drill string of fluid;

Figs. 8–9 are views similiar to Figs. 6–7, showing the tool after further manipulation of its control means, in condition for treating or producing the formation sealed off between the rams;

Fig. 10 is an enlarged view of the lower end of the tool, with lower valve uncoupled, for draining fluid from the tool, this condition being intended for use when removing the tool from the well; and

Fig. 11 is a perspective, fragmentary detail on one of the packer collar assemblies.

In these views, the entire assemblage is shown suspended on the inner communicating pipe **20** which runs the length of the tool and which in turn is supported in the well by coupling from the usual drill string of supporting tubing or pipe (not shown) leading to the surface. The upper body member **21**, central body member **22** and lower body member **23** are held in spaced relationship to each other by the sleeve couplings **24** and **25**, and the body members are all mounted for axial movement relative to pipe **20** by means contained in the upper body member **21**.

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These means consist of a chamber **28** formed in body **21** wherein a heavy duty coil control spring **26** exerts pressure against the flange **27** formed on inner pipe **20**. The movement of inner pipe **20** relative to body members **21**, **22** and **23** is therefore controlled by the movement of flange **27** in chamber **28**, flange **27** being movable downwardly against the action of spring **26** until it meets shoulder **29** formed in chamber **28** (Figs. 1, 7 and 9).

Also formed in the upper body member **21** is the upper venting outlet **30**. Vertical movement of pipe **20** relative to body member **21** brings venting port **31** formed in pipe **20** in connection with upper outlet **30** as will be further described.

The tool as illustrated is constructed with two spaced resilient packer members **35**—**35*a***, upper packer **35** being mounted between upper body member **21** and central body member **22**, lower packer **35*a*** being mounted between central body member **22** and lower body member **23**. The construction of these packers is preferably the split-sleeve ply construction described in my Serial No. 307,958, best seen in Figs. 3 and 4, the plies being four in number shown at **36**, **37**, **38** and **39**, bonded or vulcanized together adjacent their ends.

Confining the packer members **35**—**35*a*** at each of their respective ends are the packer collars, member **35** having upper collar **40** and lower collar **41**, packer **35*a*** having upper collar **40*a*** and lower collar **41*a***. The upper collars **40**—**40*a*** are secured to the lower ends respectively of upper body member **21** and central body member **22**, the details of which construction will be described below. Lower collars **41**—**41*a*** are respectively secured to the hydraulic rams or pistons **42**—**42*a*** contained in the upper ends of central body member **22** and lower body member **23**.

In the upper end of central body member **22** is formed the cylinder **43** containing the piston **42**. The cylinder **43** has feeder ports or channels **44** through which fluid under pressure may enter the cylinder from pipe **20** when ports **44** are in register with ports **45** formed in pipe **20** (Fig. 3). Centrally in body member **22** is formed the main treating and production outlet **46** which communicates with pipe **20** through ports **45** when the latter are shifted into register. Safety vents **47** prevent excessive movement of piston **42**.

The upper part of the lower housing **23** is constructed similarly to the upper part of central housing **22**, there being a cylinder **43*a***, piston **42*a***, ports **44*a***, **45*a***, and safety vents **47*a*** (Figs. 4–5).

The lower part of lower housing **23** is formed as a hollow chamber open externally through lower outlet **51**. An internal housing **52** with a series of spaced ports **53**, **54** and **55**, contains a ball valve member **56**, normally screw-attached at **57** to the lower end of pipe **20**. Member **56** is vertically movable in housing **52** responsive to the movements of pipe **20**, and is formed with an internal channel **60** which may be brought into selective registry with ports **54** or **55**. Port **53** cannot register with channel **60**, but is provided to release back pressure during movements of member **56**. The lower end of member **56** is formed in the shape of a square pin **61** to engage into a similarly shaped recess or socket **62** formed in the base of inner housing **52**. Screw connection **57** is left-handed so that engagement of pin **61** in recess **62** and rotation of pipe **20** in a clockwise direction will disconnect ball valve member 56 from pipe 20 (Fig. 10). The purpose of this operation will be explained below.

At various points throughout the tool are provided sealing rings generally designated at 58, recessed in the walls between moving parts, such as between the body members and pipe 20 or in the walls of pistons 42—42*a*. These sealing rings provide fluid-tight joints at their respective locations and may be best identified in Figs. 1–5.

The packer collar construction will now be described in particular with reference to Figs. 2, 3, 4 and 11. Upper collars 40—40*a* are secured in recesses in the lower ends of body members 21 and 22; lower collars 41—41*a* are secured in recesses in the upper ends of the movable pistons 42—42*a*. The construction and mounting of all collars being otherwise similar, a description of one of them will suffice.

In Fig. 11 a detail is shown of a ring mounting 63 (see also Figs. 1, 2 and 5) having a series of peripheral notches 64 in which are secured the inner hinged bearing or collar plates 65. The hinge pin may take the form of a pin 66 passing through holes 67 bored peripherally of rings 63 to intersect the notches 64. Collar plates 65 are shaped to lie flat over the convex tapered ends of the resilient packer members and are bonded thereto, as by vulcanization or riveting. Collar plates 65 are also tapered, being of less diameter near the hinged ends than near their tips, so that when the packer members are in collapsed condition, collar plates 65 abut and substantially cover the ends of the packer members (Figs. 1 and 2).

Also secured to ring mounting 63 overlapping the adjacent edges of collar plates 65, is a row of double leaf springs riveted or bolted to ring 63 at 68, the inner layer being designated at 70, the outer layer being designated at 71. Springs 70 and 71 are also shaped to lie flat over the collar plates 65 and are tapered as best seen in Fig. 2. Collar plates 65 and springs 70—71 should be of high tensile strength. The ring 63 is attached in the recess 74 provided in the body member or piston, as the case may be, by insertion therein and by dowels such as shown at 72 inserted in holes 73 formed in the walls of the recess and ring 63 (Figs. 3 and 11).

This collar construction is advantageously designed to resist the great a pressure resulting from actuation of the pistons 42—42*a*, the result being a longitudinal compression or wadding together of the resilient packer members 35—35*a*, as shown in Figs. 6–9. This compression causes a very forceful lateral expansion of the resilient packer members into contact with the walls of the borehole. During this operation it is essential that the ends of the packer members be securely held, and confined against movement axially of the tool.

By this collar construction it will be seen that as pressure is applied to the resilient packer members and lateral enlargement commences, collar plates 65 will separate and fan out against the resistance of the overlying springs 70—71. Collar plates 65, being both hinged to the adjacent body member or piston (as the case may be) and also bonded to the packer ends, provide a remarkably strong construction. The springs 70—71 being in overlapped relationship relative to the spaces or gaps thus formed between collar plates 65, the ends of the packer members remain protected and cannot escape from beneath the collar assembly. It will be appreciated that with the enormous pressures the tool is intended to exert, the flexible material of which the packer members is made, although of the best kind of rubber or rubber-substitute, will escape the compressive action if permitted. As the packer collars continue to expand and the packers engage the borehole walls, the tips of collar 65 likewise engage the walls, thus forming a bridge of steel between the tool and the borehole on either side of the packer member, further ensuring that the expansion of the packer in response to the pressure exerted by the piston will occur in the direction of the walls of the well.

Further by this construction, the action of the powerful leaf springs 70—71 is available to aid in the collapse of the packer members when the tool is to be withdrawn from one position in the well and removed. Springs 70—71 slide on collar plates 65 very easily due to the natural lubrication provided by the drilling mud in the well.

The novel control means for operating the tool will now be described in connection with a complete cycle of operations. In Figs. 1–5 the tool is in its primary position of adjustment for lowering into the well and ready for actuation of the resilient packers 35—35*a* which are, as shown, in collapsed condition. In this position, also, it will be seen that spring 26 holds pipe 20 in its uppermost position relative to the tool. Accordingly, ports 31 in upper body member 21 are disconnected from upper outlet 30 and sealed off between two seals 58; ports 44—45 and 44*a*—45*a* are in register preparatory to pumping fluid into the cylinders 43—43*a*; main outlet 46 is sealed from access to pipe 20; and the end of the pipe 20 is open to the ingress of fluid from the well through lower outlet 51, ports 54 and channel 60 through ball valve member 56. As the tool is lowered into the well, therefore, liquid from the well may enter the tool to equalize pressure. When pressure pumping is commenced at the surface, liquid cannot escape outwardly of the tool through ball valve member 56, the only other exits from pipe 20 being open are the ports leading to the cylinders 43—43*a*.

Pumping into the tool through the supporting pipe having driven the packers 35—35*a* into engagement with the formations of a well 50, the second positional stage of the tool controls is shown in Figs. 6–7. In these views pipe 20 has been shifted downwardly in the tool body about one-half the distance of chamber 28, the spring 26 being correspondingly depressed. Ports 31 are now in registry with upper outlet 30; ports 45—45*a* are disconnected from cylinders 43—43*a*, with the pressure left sealed off therein to maintain the packers in formation-engaging condition. Accordingly, further pressure pumping from the surface will vent the contents of well fluid from the drill string through outlet 30, back into the well.

The third positional stage of the tool is shown in Figs. 8–9, where pipe 20 has been further depressed relative to the tool, flange 27 having come into contact with shoulder 29 in chamber 28 of upper body member 21. In this position upper ports 31 are now sealed from outlet 30 and ports 45 have been brought into registry with the main treating and production outlet 46. Also, the lower ball valve member 56 has been lowered in the internal housing 52 to a point remote and sealed off from the ports therein, so that pipe 20 is sealed off from ingress or egress of fluids at its end below the packers. In this position the tool is now ready for exploiting the formations located between the packers 35 and 35*a*. Treating fluids, such as acids, may be forced into the formation through main outlet 46 if such treatment is desired. Otherwise the formation may be induced to flow its contents into the tool and thence to the surface through pipe 20 by its natural pressures aided if necessary by swabbing the drill string above the tool.

The fourth and final position of adjustment is shown in Fig. 10. When it is desired to remove the tool from its position in the well, to avoid bringing the contents of the supporting pipe to the surface, means are provided to remove the valve member 56 from the end of pipe 20 thus leaving the tool open to the well through the lower outlet 51. This is accomplished while pipe 20 is left in its lowermost (Fig. 8) position relative to the tool, the pin 61 being in engagement with recess 62, the rams remaining in engagement with the well to prevent rotation of the entire tool. The drill string carrying pipe 20 may then be rotated clockwise which will disengage the left-hand threaded connection 57. Thereafter a lifting of the supporting pipe above pipe 20 will permit spring 26 to return pipe 20 to its first position of adjustment, will re-register ports 44—44*a* with ports 45—45*a* and cause a release of pressure in the cylinders **43—43***a*. Packers **35—35***a* will collapse, aided by the action of the spring members **70—71** of the collars **40—40***a* and **41—41***a*. The tool may then be withdrawn or relocated.

From the above description the facility of the controls will be understood. The main stages of adjustment are accomplished by pumping to set the tool and lowering down on the drill string a predetermined distance, next by a further lowering on the drill string. Removal of the tool from the well is possible at any time merely by lifting on the drill string. These simple manipulations are vastly important where tools of this kind must be operated at the ends of thousands of feet of supporting pipe, many valuable wells having been lost or damaged due to faulty controls or jamming of tools in the well bore.

What is claimed is:

1. In a well tool of the type described, packer supporting means adapted to be attached to the lower end of a string of supporting pipe in a well, at least one resilient expansible packer member carried externally of said supporting means, actuating means controlled through said supporting means to force said packer member by lateral expansion into contact with the walls of said well, and collar means for confining the ends of said packer member consisting of an inner ring of bearing plates linked to said supporting means and extending over said packer ends, and at least one outer ring of spring members carried by said supporting means in overlapping relationship with the adjacent bearing plates and the spaces formed therebetween, said springs exerting compressive pressure on said bearing plates.

2. The construction according to claim 1, wherein the bearing plates are bonded to the packer ends.

3. The construction according to claim 1, wherein said packer member is composed of tubular overlapping plies of compressible material, the respective ends of said plies being bonded together to form unitary end sections.

4. The construction according to claim 1, wherein said packer member is composed of tubular overlapping plies of compressible material, respective ends of said plies being bonded together to form unitary end sections, said overlapping plies having open seams formed substantially lengthwise therein, the seams in adjacent plies being located to avoid overlapping.

5. The construction according to claim 1, wherein the actuating means includes a fluid driven piston contained in a cylinder forming part of the packer supporting means, said piston being connected to one end of said packer for longitudinal compression and consequent lateral expansion thereof, and means for delivering fluid under pressure to said piston from said string of supporting pipe.

6. In a well tool of the type described, packer supporting means adapted to be attached to the lower end of a string of supporting pipe in a well, at least one resilient expansible packer member carried externally of said supporting means, actuating means controlled through said supporting means to force said packer member by lateral expansion into contact with the walls of said well, and collar means for confining the ends of said packer member consisting of an inner ring of bearing plates linked to said supporting means and extending over said packer ends, and a plurality of layers of leaf springs carried by said supporting means in overlapping relationship with the adjacent bearing plates and the spaces formed therebetween, said springs exerting compressive pressure on said bearing plates.

7. In a well tube of the type described, hollow packer supporting means adapted to be lowered into a well, an internal pipe in said supporting means selectively movable relative thereto, said internal pipe being connected to the lower end of a string of supporting pipe in the well, a pair of spaced packer members carried on said supporting means, said supporting means also having an upper port above the packers, a central port between the packers, a lower port below the packers, and actuating ports connecting with means for forcing said packers against the well bore, said internal pipe having port means disposed therein to connect exclusively initially with said actuating ports, secondly with said upper port, and thirdly with said central port, said connections being made by successive downward movements of said internal pipe relative to said packer supporting means, the lower end of said internal pipe having port and valve means which are open to ingress only of fluid from the well in the said first and second positions, and closed in the third position, and means for disconnecting the port and valve means from said internal pipe to open the latter, said means including a threaded connection and key means operable by rotation of said internal pipe when said internal pipe is in the third or lowest position.

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