Aug. 16, 1955 K. J. FEWEL 2,715,444

HYDRAULIC PACKERS

Filed March 17, 1950 2 Sheets-Sheet 1

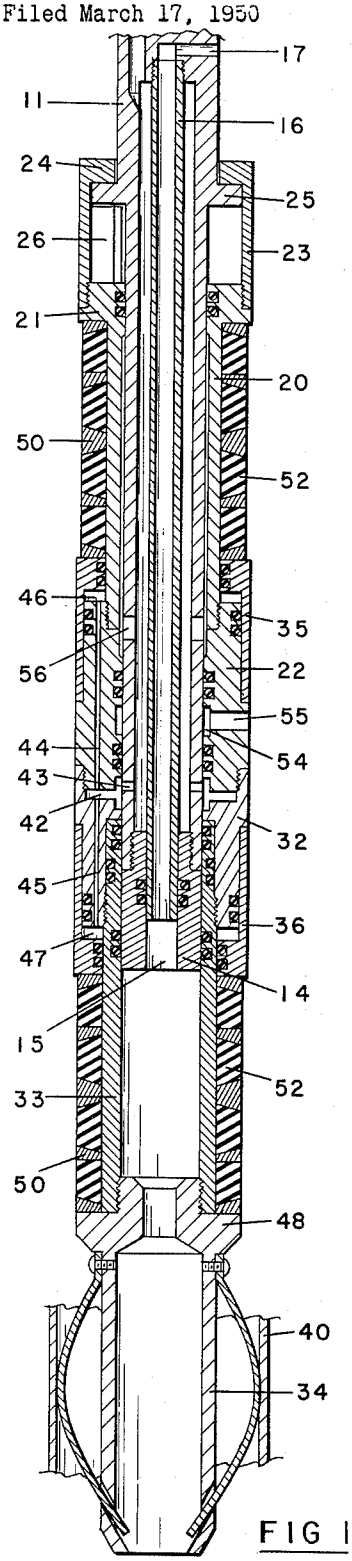

FIG 1

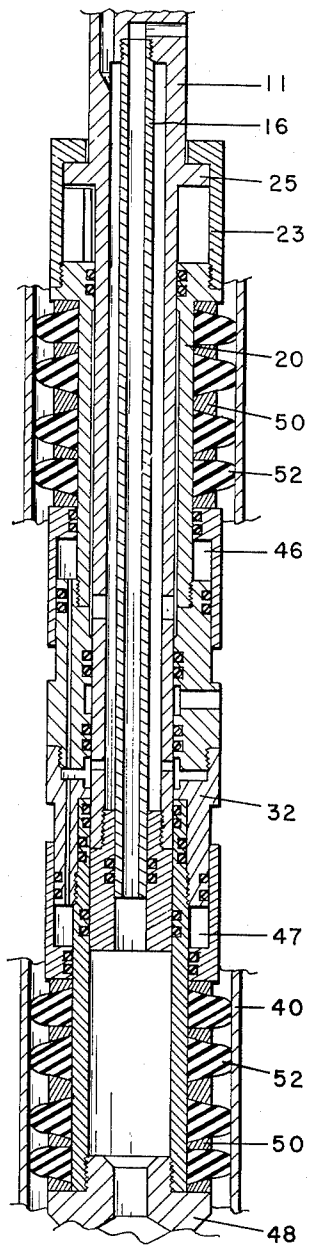

FIG 2

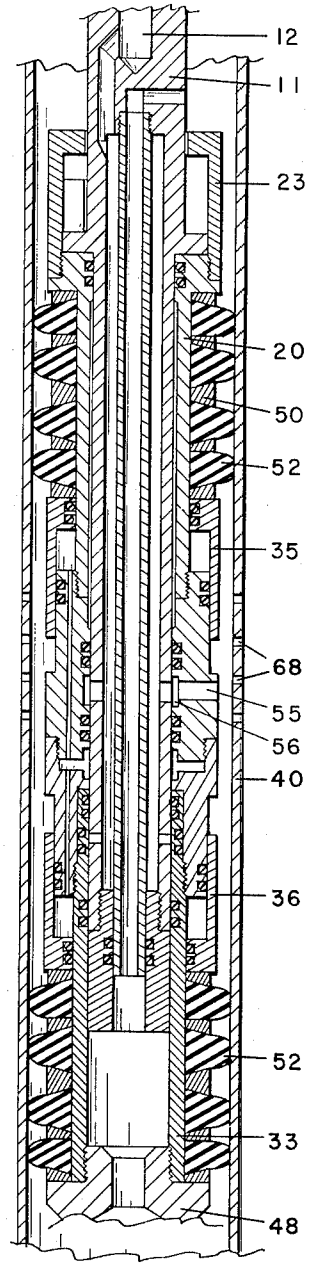

FIG 3

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FIG 4

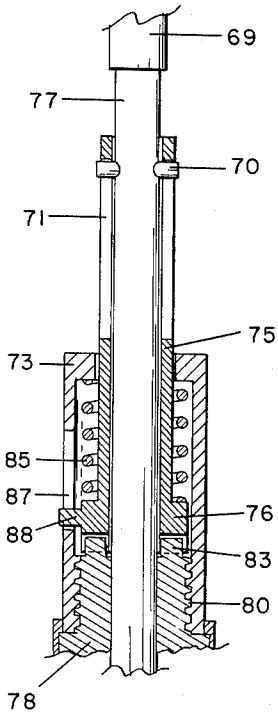


FIG 5

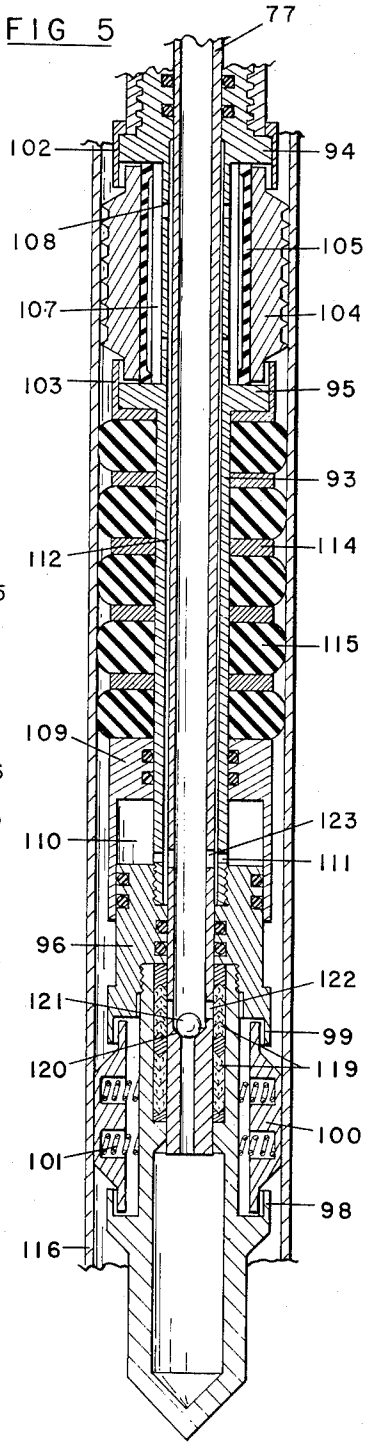
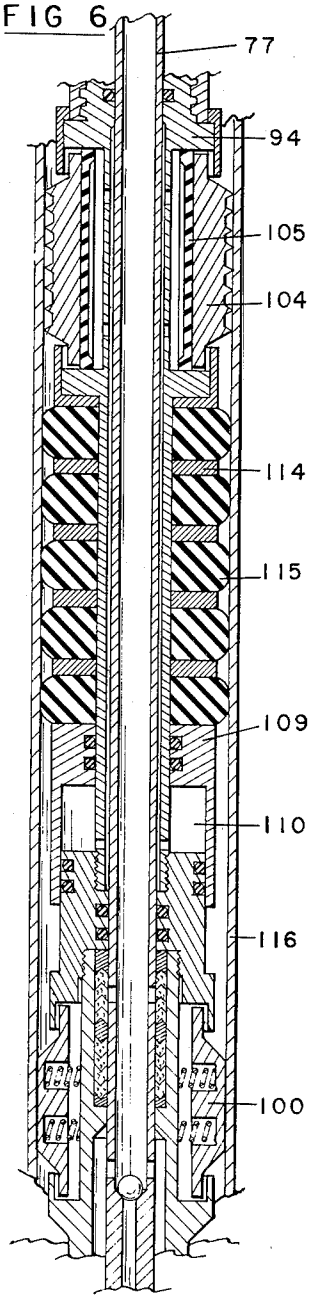


FIG 6



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HYDRAULIC PACKERS

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Application March 17, 1950, Serial No. 150,313

1 Claim. (Cl. 166—187)

This invention relates to improvements in packers for use in oil wells or the like and more particularly to packers adapted to seal the lower end of a conduit, such as the tubing within the bore of an oil well as an aid in "squeeze cementing" the well.

The provision of packers for sealing tubing in a well bore is common and the art may be said to be well developed. Typical examples of prior patents showing packers suitable for use in squeeze cementing of oil wells are Halliburton 2,235,318 issued March 18, 1941; Stoddard 2,274,940 issued March 3, 1942, and Verheul et al. 2,341,832 issued February 15, 1944.

However, the prior art still leaves something to be desired in the provision of means for preventing the flow of fluid under certain conditions. Swab cups, such as proposed by Stoddard and Verheul et al. are often not satisfactory because they cannot be expanded to maintain a seal under high pressure. On the other hand, with the arrangement of the Halliburton patent cited, the inflated packers do not maintain their seals with the casing if the pressure goes off. The prime purpose of the present invention is to provide a packer assembly wherein packers expanded by fluid pressure and slips set by fluid pressure may be held expanded and set even though the pressure is released.

Accordingly, it is an object of the present invention to provide a novel arrangement for setting and securing tubing packers in casing in a borehole in such a way as to seal the bore against pressure and at the same time prevent the movement of fluid either upwardly or downwardly in the annulus between the tubing and casing.

Another object of this invention is to provide an arrangement for sealing a conduit in a well bore by the use of a packer which can be collapsed when desired so as to allow the flow of fluid past it and thus eliminate wear on the packer, such as is experienced when rubber cups like those of the Stoddard patent cited above are used.

A further object of the invention is to provide a hydraulic packer having an arrangement for securing it in the well with sealed-in fluid pressure, the arrangement being such that upon an increase in pressure, either above or below the packer, it will be secured more firmly in the well.

A still further object of the invention is to provide two packers mounted on a common mandrel and arranged to seal the end of a conduit in a well bore and to be set and sealed in set portion by hydraulic means, such packers being compressed rather than inflated, upon expansion in order to provide a more substantial seal than has been obtained heretofore.

Still another object of the invention is to provide a novel safety joint structure for use with a squeeze packer.

These and other objects of the invention are accomplished by the hereinafter described embodiment shown in the accompanying drawings, wherein—

Fig. 1 is a longitudinal sectional view of apparatus constructed in accordance with the principles of the invention, the parts being shown in the positions they occupy when the apparatus is being lowered into the well;

Fig. 2 is a longitudinal sectional view of a portion of the apparatus shown in Fig. 1, with the parts being shown in the position they occupy when the packers are set;

Fig. 3 is a longitudinal sectional view similar to that of Fig. 2, but showing the packers sealed in a set position, the various parts shown being in the positions they occupy during the squeeze cementing operation on the well;

Figs. 4 and 5 are contiguous views of portions of a modified form of the invention. Fig. 4 shows the upper portion of this embodiment partly in elevation and partly in longitudinal section; and

Fig. 5 illustrating the positions of the parts when the packer is initially set; and

Fig. 6 is a longitudinal sectional view of a portion of the embodiment of Figs. 4 and 5 indicating the position of the various parts during the squeeze cementing operation on the well.

The embodiment of the invention particularly illustrated in Figs. 1, 2, and 3, comprises a pair of packers mounted on an operating pipe or mandrel designated **11**, which mandrel is attached to a conduit such as tubing for lowering it into the bore of a well. At its upper end the mandrel has a bore **12** in communication between the tubing and the main bore of the mandrel. At its lower end, the mandrel is closed by a plug **14**. The plug **14** has a passage **15** therethrough but fluid cannot at any time flow from the interior of the mandrel **11** to a point beneath the plug **14**. The passage **15** is connected to an inner by-pass pipe **16** which is in communication with a lateral passage **17** at the upper end of the mandrel **11**.

A cylinder **20** is mounted for sliding movement on the mandrel **11**. This cylinder is provided at its upper end with an outwardly extending flange **21**. At its lower end it is threaded into a valve cylinder **22**. The flange **21** of the cylinder **20** may be threaded for securing a ring **23** thereon. The ring **23** has an inturned annular flange **24**, which cooperates with an outstanding annular flange **25** on the mandrel **11** to act as a stop for limiting relative movement between the mandrel and the cylinder **20**.

Within the ring **23** the cylinder **20** is provided with a vertically extending spline or guide **26**. This spline terminates short of the flange **25** on the cylinder **20** when the parts are in the position shown in Fig. 1. The outstanding flange **25** of the mandrel is provided with a notch to receive the spline **26**, so that when the mandrel **11** is in its lowered position, as shown in Fig. 3, it is prevented from rotating with relation to the cylinder **20**. In its uppermost position, as shown in Figs. 1 and 2, the flange **25** clears the spline **26**, and the mandrel **11** can then be rotated in the cylinder **20**.

The valve cylinder **22**, to which the cylinder **20** is attached, is threaded into another valve cylinder **32**, which in turn is connected to a depending cylinder **33** carrying at its lower end a foot piece **34**. It will be seen that the cylinder **20**, valve cylinders **22** and **32** and the cylinder **33** constitute a continuous sleeve through which the mandrel **11** can move as a valve body. The parts thus constitute a sleeve valve which can be operated from the surface of the ground by manipulation of the tubing or conduit to which the mandrel **11** is attached.

Cylindrical packer shoes **35** and **36** are positioned over the valve cylinders **22** and **32**, respectively. As shown the shoe **35** slidably engages the cylinder **20** while the shoe **36** slidably engages the cylinder **33**.

An annular chamber **42** is provided in valve cylinders **22** and **32**, which at times is in communication with the ports **43** in the mandrel **11** communicating with the main bore thereof. Passages **44** and **45** lead from the cham-

ber 42 to the interiors 46 and 47 of the respective shoes 35 and 36 in order to conduct fluid from the main bore of the mandrel 11 into the shoes when the ports 43 are in alignment with the chamber 42.

Each of the packers is of the compression type and preferably comprises annular elements 50, which are of generally wedge shape in cross-section, and alternate annular resilient members 52. As will be seen from an inspection of Figs. 1 and 2, when the resilient members 52 are compressed between the elements 50, upon movement of the shoes 35 and 36 toward the flange 21 and shoulder 48, respectively, the members 52 will expand outwardly and be pressed into close engagement with the casing 40. When the shoes 35 and 36 are moved away from the flange 21 and shoulder 48, respectively, the resilient members 52 will contract away from the casing 40 thus returning the apparatus to released position.

The piston member 22 has an internal annular groove 54 therein, which opens through a pasasge 55 into the casing 40 and the mandrel 11 has ports 56 therein, which ports, at times, may be brought into registration with the groove 54 to permit the flow of fluid from the main bore 13 of the mandrel 11 through the piston member 22 into the casing 40 or vice versa. Packing rings such as "O-rings," may be provided between the various parts as illustrated.

In making use of the apparatus of Figs. 1, 2, and 3, described above, the mandrel 11 is attached to an operating pipe, not shown, with the passage 12 of the mandrel in communication with the pipe. With the parts in the positions shown in Fig. 1, the apparatus is lowered into the well to the desired location. As shown in Fig. 1, the flange 25 of the mandrel 11 is at its uppermost position, the packer members are in retracted positions, and the ports 56 are out of registration with the chamber 54 of the valve cylinder 22.

When the apparatus is in the desired position in the casing or bore of the well, fluid under pressure is admitted through the operating pipe and passage 12 of the mandrel 11 into the main bore thereof. The fluid passes through the port 43 into the chamber 42 and through the passages 44 and 45, respectively, into the chambers 46 and 47 of the shoes 35 and 36, moving them longitudinally of the mandrel 11 and the nipple 33, respectively, and compressing the packer between the shoes and the flange 21 and shoulder 48, respectively, to expand the packer elements 52 into engagement with the casing 40 as shown in Fig. 2.

As soon as the packers are thus set in the casing or bore, the mandrel 11 may be rotated until the notch in the flange 25 registers with the spline 26. The mandrel may then be moved downwardly to bring the ports 43 out of registration with the chamber 42, thus locking the pressure in the shoes 35 and 36 so that the packers remain in set position. The mandrel 11 with its ports 43, in cooperation with the chamber 42 thus constitutes a sleeve valve which first supplies fluid under pressure to the packer shoes 35 and 36 and then seals in that fluid under pressure to hold the packers in set position. Further movement of the mandrel 11, to the position in which the flange 25 engages the top of the cylinder 20, as shown in Fig. 3, then results in bringing the ports 56 in registration with the groove 54, and fluid under pressure may then pass from the main bore 13 of the mandrel 11 through the groove 54 and out of the passage 55 into the casing or bore of the well. With the apparatus positioned as just described, it is possible to treat the formations adjacent the apparatus by forcing fluid into the same through perforations 68 in the casing 40, or if desired, fluid from the earth formations may be withdrawn through the perforations 68 and flow out through the apparatus for testing or production. It will be noted that the casing or bore of the well below the apparatus is in communication with the portion of the casing or well bore above the apparatus by way of passage 17 in the mandrel, the internal pipe 16, passage 15 in the plug 14, nipple 33, and the foot piece 34. Thus production or testing of the well may proceed at the same time that the formation horizontally adjacent the apparatus is being tested or treated as by the injection of acid or cement slurry under pressure.

To release the apparatus, the mandrel 11 is raised, bringing the port 56 out of registration with the groove 54 and the passage 55. This closes off the main bore of the mandrel 11 from the casing, and brings the ports 53 into registration with the chamber 42 to relieve the pressure in the shoes 35 and 36. This permits the packer elements 52 to contract and release the apparatus. The apparatus may then be withdrawn from the well, or moved to a new location therein for further testing or treatment of the earth formations.

The modification of the invention shown in Figs. 4, 5, and 6, makes use of only a single packer, instead of two as in the previously described form. The apparatus, as illustrated in Figs. 4, 5, and 6, is attached to tubing 69. An operating pipe or mandrel 77 is connected to the lower end of the tubing 69 and it extends down through the safety joint and through a major portion of the packer assembly, as shown in Figs. 4 and 5. The packer assembly and the safety joint are associated with a sleeve 93 on the mandrel 77.

The suspending means for the safety joint and packer assembly consists of a set of pins 70 on the mandrel 77 which supports a hanger 75 for limited longitudinal movement with respect thereto, the pins 70 extending into slots 71 of the hanger 75.

The back-off safety joint includes a housing 73 around the lower portion of the hanger 75. The hanger 75 is provided with a flange 76 at its lower end. An enlargement 78 on the sleeve 93 is connected by safety or "back-off" threads 80 to the housing 73. The arrangement is such that if the enlargement 78 is disconnected from the housing 73 at the back-off threads 80, the tubing may be withdrawn from the well leaving the sleeve 93 with the slips and packer thereon in the well.

The upper end of the enlargement 78 is clutched as indicated at 83, with the hanger 75. Within the housing 73, a spring 85 is positioned between the flange 76 of the hanger and the top of the housing 73. Thus there can be no relative rotation between the enlargement 78 and the hanger 75 until the enlargement 78 is held stationary in the well bore while the tubing is raised to compress the spring 85. The jaws of the clutch 83 then separate and the housing 73 may be backed off. The housing 73 has a slot 87 therein and the hanger 75 has a pin 88 which fits in this slot so that the housing 73 may be rotated when desired by rotation of the tubing 69 and mandrel 77.

As shown in Figs. 5 and 6, the sleeve 93 has spaced apart flanges 94 and 95, and is threaded at its lower end for the attachment thereto of a piston member 96. The piston member 96 is in turn connected to the foot piece 97 which has an annular flange 98 mediate its ends.

An annular flange 99 is also formed on the lower end of the piston 96, and radially spaced drag shoes 100 are positioned between the flanges 98 and 99. The shoes 100 are urged outwardly by coil springs 101 into engagement with the casing 116 in order to maintain the apparatus in centered position in the well. A ring member 102, having an inturned flange thereon, is positioned over the flange 94 of the sleeve 93 and another ring 103, having an inturned annular flange, is positioned over the flange 95 of the sleeve 93, these rings extending beyond the respective flanges and serving to retain slips 104 in position between the flanges 94 and 95. Expansible pads 105 are mounted beneath the slips 104 to force the same outwardly when fluid pressure is exerted in chamber 107 through ports 108 in the sleeve 93. The bore 112 of the sleeve 93 is larger than the outside diameter of the mandrel 77, as shown, so that fluid can flow along the sleeve.

A packer shoe **109** is positioned over the piston member **96** providing a chamber **110** which communicates by ports **111** with the bore **112** of the sleeve **93**. Between the shoe **109** and the ring **103** on the flange **95** the compression type packer is positioned. This packer is made up of spaced ring elements **114** alternately positioned with resilient packing elements **115**, adapted, when compressed, to be forced into engagement with the well casing **116** to form a fluid tight seal therewith.

The mandrel **77** extends completely through the sleeve **93**, the piston member **96**, and into the foot piece **97**, there being a suitable packing **119** located in the foot piece to form fluid tight engagement with the operating pipe. The mandrel **77** has a restriction near its lower end forming a seat **120** for a ball valve **121**, which closes the pipe to downward flow of fluid therefrom. Ports **122** are provided in the mandrel **77** just above the ball valve **121**, and other ports **123** are spaced above the ports **122** to transmit fluid to the interior of the sleeve **93** when desired. Thus the mandrel **77** with its ports **123**, in cooperation with the ports **111** in the sleeve **93** constitute a sleeve valve which can supply fluid under pressure to the shoe **109** to set the packer and then can seal-in that fluid under pressure to hold the packer set. In the same way this sleeve valve controls the slips **104**. The slips can be set and then the fluid pressure sealed in to hold them set while squeeze operations are performed with the mandrel **77** moved to any desired position.

The modified form of the invention just described is used as follows:

The packer apparatus is lowered into the well with the clutch in the position shown in Fig. 4 and with the packer members **115** in contracted positions out of contact with the casing. As soon as the apparatus reaches the desired depth in the well, the ball valve **121** in the mandrel **77** comes to rest on valve seal **120**. Pressure fluid is then exerted in the mandrel **77**, whereupon pressure is applied, through the ports **123** to the bore **112** of the sleeve **93** and thence through ports **108** into the chamber **107** to move the pads **105** and force the toothed slips **104** into biting engagement with the casing **116** to retain the packer apparatus in position.

Pressure fluid also flows from the bore **112** of the sleeve **93** through ports **123** and **111** into the chamber **110** of packer shoe **109**. This moves the shoe upwardly from the piston member **96**, compressing the packing members **115** between the rings **103** on flange **95** and the shoe **109**, and expands them into sealing engagement with the casing. With pressure being maintained within the mandrel **77**, the tubing **69** may then be lowered. Due to the provision of a slip joint, the mandrel **77** may be lowered while the packer assembly remains stationary, the parts then taking the position shown in Fig. 6.

Downward movement of the mandrel **77** with respect to the packer assembly lowers the ports **123** to a point beneath packing **119** to cut off the flow of pressure fluid into the bore **112** of the sleeve **93**. The pressure in the chambers **107** and **110** is maintained however, so that the slips and packer remain in set position. Downward movement of the mandrel **77** also brings the ports **122** into the foot piece **97** so that fluid communication is established between the mandrel **77** and the portion of the well beneath the packer.

When it is desired to release the apparatus, the mandrel **77** is drawn upwardly to close off the ports **122** and bring the ports **123** again into the bore **112** whereupon the pressure fluid in the chambers **107** and **110** can escape into the mandrel and release the slips **104** and resilient members **115** from engagement with the casing.

It is to be noted that in the condition of the apparatus shown in Fig. 6, if the apparatus is set in the well for a certain pressure and the pressure below the apparatus becomes higher, then there will be a tendency for the shoe **109** to move downwardly until the pressure inside the chamber **110** balances that in the casing below. Such increased pressure is transmitted to the slip members **104** through the ports **111**, bore **112** and ports **108** to force the slip members more firmly into engagement against the casing as the pressure increases.

On the other hand, should the pressure above the apparatus become higher than the effective pressure setting the apparatus, then the resilient members **115** and the shoe **109** will move downwardly, increasing the pressure behind the slip members **104** in the same manner as outlined above, thus setting the apparatus more firmly in position.

The invention provides apparatus by which it is possible to treat or test a well, and affords means by which the earth formations throughout the well may be tested or treated without interfering with production from other formations.

While the arrangements illustrated are described as mounted in casing in a well bore, it will be apparent that by making suitable changes, they may be used in open hole as well. Various changes may be made without departing from the spirit of the invention or the scope of the annexed claim.

I claim:

Apparatus for sealing the lower end of a conduit in a well bore comprising, in combination, a mandrel having a plurality of vertically spaced ports therein, a sleeve mounted on said mandrel for longitudinal movement with respect thereto and having a plurality of vertically spaced ports which may be brought into alignment with certain ports of the mandrel, means for connecting the mandrel to the conduit, a plurality of sleeve valves including said mandrel and said sleeve operable from the surface of the ground by manipulation of the conduit to selectively control the alignment of ports in said mandrel with ports in said sleeve, two spaced compression type packers mounted on the sleeve, each being adapted to be expanded into fluid-tight engagement with the wall of the well bore, two shoes, one for each packer, slidably mounted on the sleeve for expanding the packers hydraulically, said shoes having a chamber associated therewith adapted upon alignment of certain ports in said mandrel with certain ports in said sleeve to be supplied with fluid under pressure, and means including one of said sleeve valves for supplying fluid under pressure to said chamber to move said shoes and expand said packers and operable by subsequent manipulation of said mandrel to seal in said chamber the fluid under pressure and hold said packers expanded whereby variable pressure operations may be performed in the well bore between the two packers through another of said sleeve valves without altering the expanded position of said packers.

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