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2,854,080

WELL PACKER

Filed Dec. 23, 1954

3 Sheets-Sheet 1

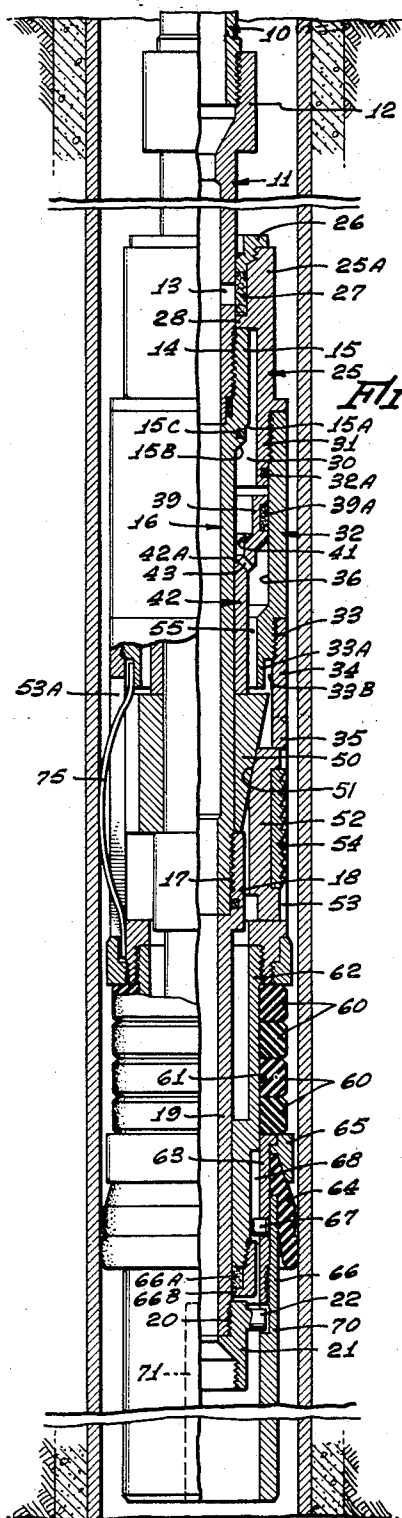


FIG. 1.

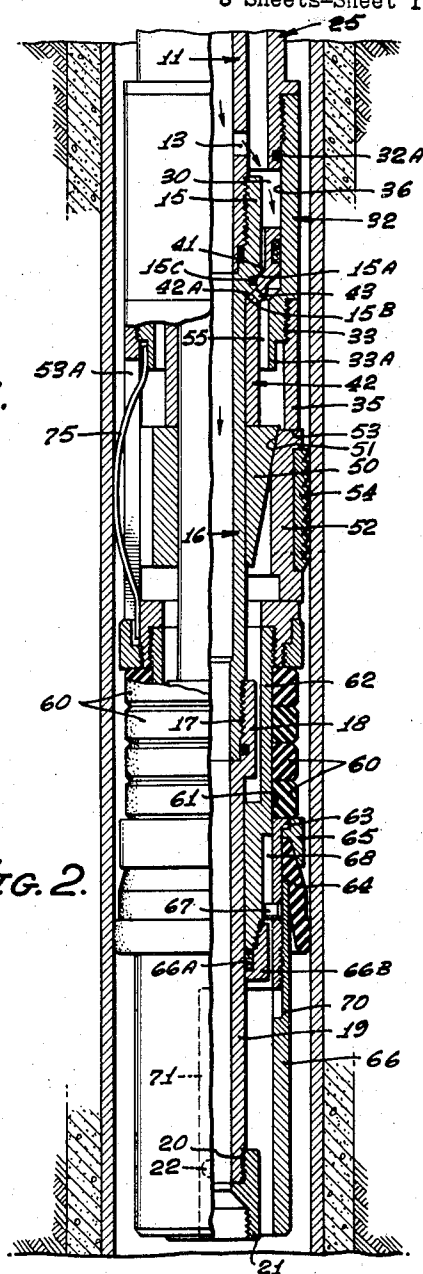


FIG. 2.

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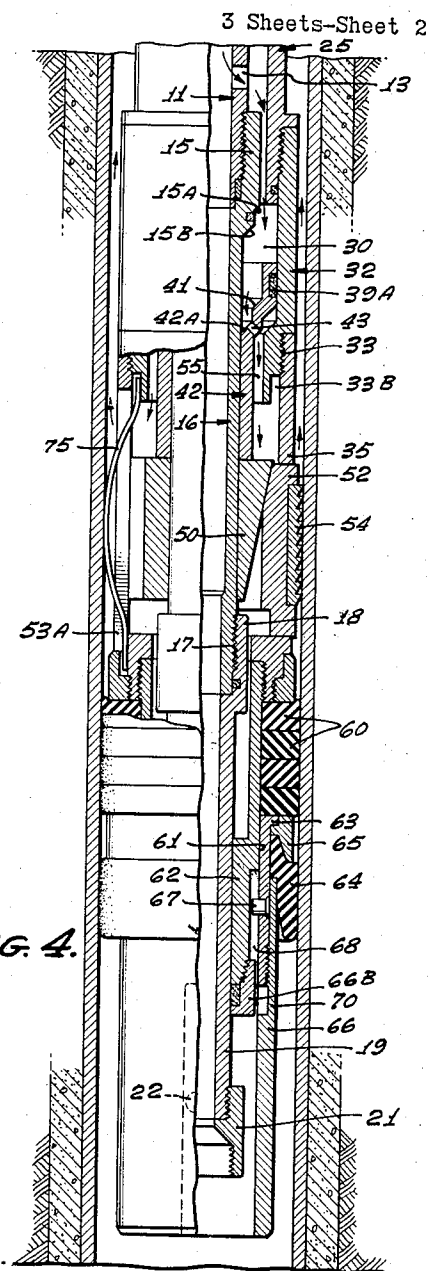
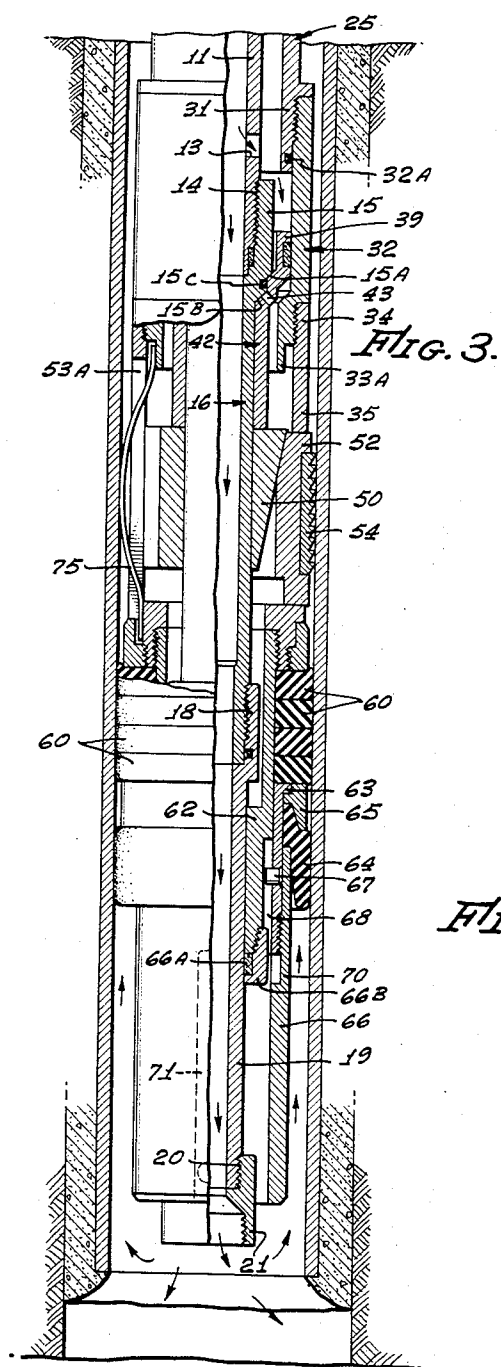
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3 Sheets-Sheet 3

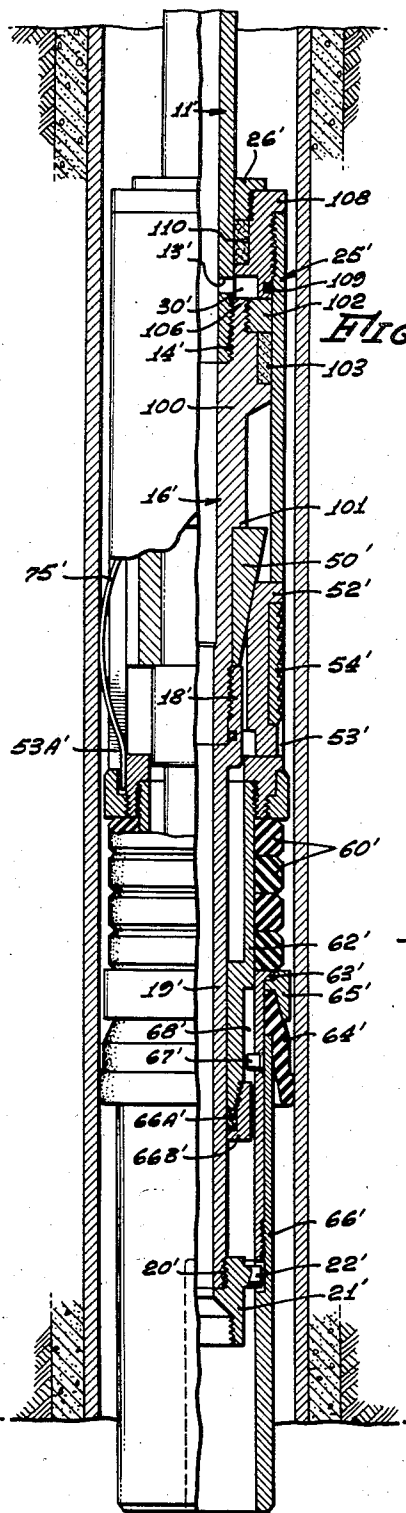


FIG. 5.

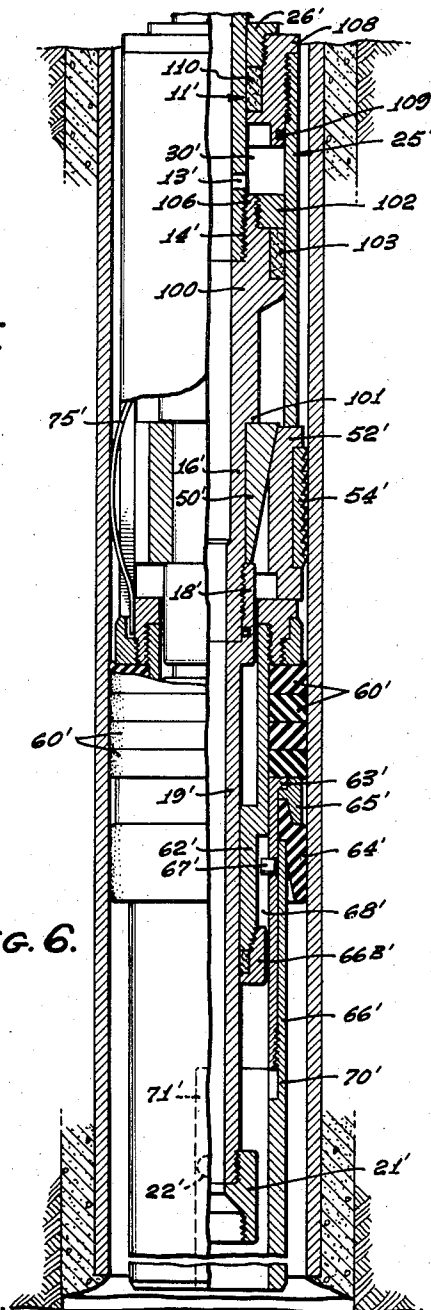


FIG. 6.

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## WELL PACKER

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13 Claims. (Cl. 166—140)

The invention relates to packers for use in cementing, acidizing, fracturing or similar oil well operations.

One of the primary problems in the design and operation of well packers is the retention of the packer at the desired point in the casing, tubing, or bore which is to be packed off. In the use of such devices, particularly in cementing and fracturing operations, the pressure below the packer exceeds the pressure above it and hence there is a tendency for the packer to be forced upward under the differential pressure. Pressure slips or other wall engaging means have been employed in order to preclude any such inadvertent movement. Also the weight of the drill string to which the packer is secured has been used to offset the tendency of the packer to float upward. However both of these expedients have been found to be inadequate. Mechanical failures occur in the slip expanding mechanism, and frequently the weight of the drill string is insufficient to compensate for the excessive pressure below the packer.

It is therefore among the primary objects of the present invention to provide an improved means for securely anchoring a well packer at a desired location within a well bore casing or tubing.

More specifically, it is an object of the present invention to provide a packer wherein means are provided for directly applying the pressure seeking to move the packer upward to the slip hold down mechanism so that the two effects tend to balance each other out.

It is a further object of the invention to provide a packer wherein anchor slips are set mechanically and maintained in such position by pressure means responsive to the same pressure that tends to force the packer upwardly.

It is a further object of the invention to provide a packer wherein anchor slips are set mechanically, packer rings are pressure expanded to seal against a casing, and the same expanding pressure is independently effective to maintain the slips in set position.

A still further object of the invention is to provide an improved well packer whose rugged construction renders it effective, economical, and durable over a long period of time.

Numerous other objects and features of the present invention will be apparent from a consideration of the following specification taken in conjunction with the accompanying drawings in which:

Figure 1 is a longitudinal section of one embodiment of the present invention showing the parts in retracted position as in "running in" the tool.

Figure 2 is a similar sectional view of the device of Figure 1 showing the parts in position with the slips set, and prior to expansion of the packer rings.

Figure 3 is a view illustrating the relationship of parts when cement or fracturing fluid is being forced into the well, the slips and packer rings being in set position.

Figure 4 is a view similar to Figure 3 showing the first step in releasing the packer for withdrawal from the well.

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Figure 5 is a view similar to Figure 1 of a modified form of the present invention with the parts in retracted position; and

Figure 6 is a view of the modified construction of Figure 5 with the parts in set position similar to the relationship of parts shown in Figure 3.

In general terms, the invention may be defined as comprising a hollow inner mandrel through which fluid may pass, an outer mandrel enveloping the inner mandrel, radially movable slips carried by the outer mandrel, and packer rings which are pressure expanded to seal against the walls of the casing within which the tool is suspended. The slips are actuated outwardly by the camming action of a hollow cone mounted on the inner mandrel. In both forms of the invention the pressure which expands the packer rings is also effective to act upon and maintain the set of the slips. This effect counterbalances pressure tending to float the packer loose from the casing walls. In the forms of the invention shown in Figures 1-4 the set maintaining pressure is applied by means of a piston sleeve bearing on the cone. In the second form of the invention the inner mandrel has an integral sub which bears on the cone at one end, and is acted upon at its other end by the pressure fluid.

Referring to the drawings, the first form of the packer illustrated in Figures 1 to 4, comprises a tubular inner mandrel adapted to be secured to a drill string either directly or through the medium of a by-pass valve, not shown. For the purpose of this illustration such connecting equipment is indicated by the numeral 10 in Figure 1. The inner mandrel comprises an upper section 11 having an internally threaded collar 12 for attachment to the member 10. It has a side port 13 intermediate its ends and spaced downwardly from the collar 12. The lower extremity of the upper section 11 of the mandrel is externally threaded as at 14 to receive thereover the internally threaded collar 15 of a central internal mandrel body section 16. At the junction of the collar 15 with the main body of the section 16 the external face of the lower end of the collar is formed with a pair of spaced frusto conical seats 15A and 15B between which is a packing ring 15C. The central body section 16 provides a relatively long smooth cylindrical surface terminating at its lower end in external threads 17. The threads 17 receive an internally threaded collar 18 of the upper end of a bottom mandrel section 19. The lower end of the lower section 19 is externally threaded as at 20 and receives thereover a threaded end member 21 from which extends a pin detent 22 forming part of a releasable J slot connection hereinafter discussed.

The outer mandrel is mounted on the inner mandrel for limited relative longitudinal movement with respect thereto, when released for such movement. It comprises an upper cylindrical section 25 having a head 25A to which is threaded a gland nut 26 which secures packing 27 between itself and an internally extending flange 28 formed on the head 25A. The packing 27, together with the nut 26 and flange 28, is slideably movable upon the section 11 of the inner mandrel between the lower face of the collar 12 and the upper face of the collar 15, as will be noted from a comparison between Figures 1 and 2. Upon downward movement of the inner mandrel from the position of Figure 1 to that of Figure 2, the nut 26, packing 27, and flange 28 will be above the port 13. In this latter position pressure within the mandrel may be transmitted through the port 13 to chamber 30 formed within the upper portion of the section 25, as and for the purpose hereinafter set forth. The lower end 31 of the upper section 25 of the outer mandrel threadedly engages the upper end of an upper intermediate outer mandrel section 32, and is fluid sealed thereto by means of packing ring 32A. The lower end of the intermediate

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mandrel section 32 is externally threaded as at 33 to receive the upper end 34 of a lower intermediate sleeve section 35. Within the upper end 34 of the intermediate section 35, the end of the upper section 32 extends in the form of an inwardly spaced flange 33A, forming a channel 33B. Mounted for sliding movement in sealing engagement with the inner wall 36 of the section 32, is the head 39 of a piston sleeve 42. The head 39 carries packing ring 39A to effect the seal between the piston sleeve 42 and the wall 36. Directly below the head 39 the sleeve 42 is formed with an internal frusto conical surface 41 adapted to sealingly engage the seat 15A. A spaced companion frusto conical surface 42A cooperates with seat 15B to open or close off port 43.

Conical slip actuator 50 is slideably mounted on the outer face of the inner mandrel member 16. The outer conical face of the member 50 engages conforming surfaces 51 on the inner face of radially movable slips 52. The slips move through windows 53 in the portion 35 of the outer mandrel. The slips 52 are provided with removable bits 54 having upwardly facing wickers adapted to engage the well casing to increase the frictional grip of the slips thereagainst. Channel 55 between the lower end of the sleeve 42 and the lower end of the outer mandrel 32 provides a flow passage, when the port 43 is open, for the discharge of drill string fluid from the pressure chamber 30 outwardly through the slip windows 53 and the spring windows 53A.

Resilient packer rings 60 are formed of rubber, neoprene or like material and are seated upon the outer surface 61 of the lowermost outer mandrel section 62. Slideably mounted on the surface 61 there is provided a packer follower member 63 of generally cylindrical form which has mounted thereon a cup type sealing member 64 secured by means of a ring 65 and an extension skirt 66. The lower inner mandrel section 19 slides within the lower outer mandrel section 61. Sealing relationship is maintained between these two sections because of packing 66A, held in place by gland nut 66B.

A pin 67 projects inwardly from the member 63 to be received in a guide slot 68 so as to preclude inadvertent relative rotation of parts. The inner face of the extension 66 is also provided with a J slot. The J slot has a peripheral portion 70 and a longitudinal extension 71 communicating therewith to receive the detent 22.

In operation of this form of the apparatus the tool is in its contracted position as shown in Figure 1. The detent 22 is in the upper circular portion 70 of the J slot. In this position the packer rings 60 are released and free of contact with the well casing. The slips 52 are similarly retracted and no radial pressure is applied thereto by the cone 50. Sealing member 64 is in contact with the casing so that skirt 66 is kept stationary. It will also be noted that in this position the port 13 is closed by the packing 27 and fluid pressure is not admitted to the chamber 30 above the sleeve 42. With the parts thus arranged, as in Figure 1, the tool is lowered into the casing to the desired position where it is to be set for the pumping therethrough of acids, fracturing fluid, or cement.

When at the desired position, the drill string 10 is rotated to move the detent 22 into alignment with the longitudinal portion 71 of the J slot and thereafter the string is further lowered to move the inner mandrel downwardly with respect to the outer mandrel, and the parts supported thereby. In this connection it will be noted that stabilizer springs 75 are provided intermediate the slips 52 so as to maintain an operating friction between the outer mandrel and the casing so that upon release of the J slot the outer mandrel remains stationary while the inner mandrel moves downwardly.

The arrangement of parts after downward movement of the inner mandrel whereby the slips are set is depicted in Figure 2. As the inner mandrel moves down, the shoulders 15A and 15B engage the shoulders 41 and 42A of the sleeve 42 so that continued downward movement

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of the inner mandrel moves the sleeve downwardly therewith. Since the lower end of the sleeve 42 rests upon the upper face of cone 50 the cone will be moved downwardly and will cam slips 52 outwardly into engagement with the casing walls.

It is to be noted that although downward movement brings the port 13 into communication with the space 30 above the piston head of the sleeve 42, it is not contemplated that fluid pressures are at this time effective in the setting of the slips. In the present invention the slips are set by purely mechanical action as by lowering the inner mandrel with respect to the outer mandrel.

With the slips thus set and the parts in the relationship shown in Figure 2, cement, fracturing fluid, acid or like material may be admitted down through the hollow central mandrel as indicated by the arrows of Figure 3. Since the fluid flows out through the bottom of the packer, the first action of the upward pressure from below the packer is to force the cup 64 upwardly. This slides the member 63 upwardly on the surface 61 to compress the packer rings 60 and radially expand them for sealing contact against the casing. By this arrangement it will be seen that the packer rings constitute a supplement to the cup 64 in sealing the packer against upward passage of fluid. As such pressure, applied through the hollow central mandrel increases, there is of course increased upward pressure on the inverted cup 64 which is transmitted through the packer rings as a general upward pressure seeking to lift the outer mandrel. Such lifting is resisted by the engagement of the slips with the inner face of the casing. In addition, as explained below, downward pressure is present to balance out the upward pressure.

Pressure is admitted through the port 13 to the chamber 30 above the piston head of the sleeve 42. Port 43 of the sleeve is at this time closed by surface 15B of the inner mandrel and thus pressure does not escape through the port but acts as a downward force on the piston sleeve 42. This in turn further presses cone 50 downward, and thus the slips 52 are wedged outwardly to grip the casing wall more tightly. It is seen that although pressure is not required to set the slips, pressure is effective to maintain an outward force on the slips which balances the force applied below the packer tending to raise the outer mandrel.

It should also be noted that the weight of the drill string is at all times effective to maintain a downward force on the inner mandrel. This keeps sleeve member 42 positioned against shoulders 15A and 15B, and port 43 is closed off. Without this force, pressure would bleed off through port 43, and the radial thrust on the slips 52 would be diminished.

At the conclusion of the pressure cycle the packer may be relaxed by upward movement of the drill string to the position shown in Figure 4, at which time the port 43 is opened and fluid entrapped in the chamber 30 is released.

Since the member 42 is then free of any downward pressure, by either fluid force or engagement by the shoulders of the inner mandrel, the cone is free to slide upwardly on the inner mandrel to permit inward radial movement of the slips 52. Pressure within the bore is then diminished to allow the packer rings to retract to the relaxed position of Figures 1 and 2. By continued upward movement of the drill string the packer may then be easily removed. As the inner mandrel is lifted by the drill string the detent pin 22 again registers with the horizontal section 70 of the J slot and a fractional rotation of the drill string will lock the detent in the horizontal portion 70 so as to secure the parts against inadvertent expansion as the tool is retrieved.

The embodiment shown in Figures 5 and 6 is generally similar to that which is illustrated in Figures 1-4. Like parts have therefore been numbered identically, but have been primed. This embodiment is somewhat simplified in that the sleeve 42 has been eliminated. The inner

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mandrel section 16' is formed with an upper piston portion 100 which has a shoulder 101 that bears directly on cone 50'. The cone 50' is held firmly between shoulder 101 and collar 18'. The piston portion 100 carries a retaining ring 102 for packing 103. The retaining ring 102 together with end face 106 of the piston portion 100 form the bottom of pressure chamber 30'.

The upper portion of the outer mandrel section has also been modified in that insert 108 is separate from and threaded into section 25'. A seal ring 109 prevents fluid flow between these two parts. Packing 110 is carried between insert 108 and gland nut 26'. Packing 110 is positioned so that it never closes off flow through port 13'.

The operation of this embodiment is the same insofar as the setting action is concerned. When the packer is set, fluid pressure within chamber 30' acts downward on ring 102, end face 106, cone 50', and results in outward movement of slips 52' to help counter the upward force exerted on seal cup 64' and skirt 66'.

It will be noted that the release of the packer is substantially the same as with the embodiment of Figures 1-4. There is a difference, in that pressure can not bleed out from the pressure chamber 30' through the slip windows 53' and the spring windows 53A' to help release the slips 52'. The desired bleeding action is made to take place through port 13' and is controlled by a suitable by-pass valve above the packer. The release of pressure allows the slips 52' to return inwardly, and the packer rings 60' to contract to nonactuated diameter so that the packer can be removed from the hole.

From the foregoing it will be seen that the invention provides an improved packer which is retained in position by means of a unique pressure balancing arrangement. It will of course be understood that the invention is not limited to the specific structure herein presented and that numerous changes, modifications, and equivalents may be utilized without departing from the spirit or scope thereof as defined in the following claims.

What we claim is:

1. In a device of the character described an inner mandrel, an outer mandrel coaxially mounted thereon, slips carried by said outer mandrel, a slip actuating cone on said inner mandrel for extending said slips outwardly of said outer mandrel, a pressure chamber formed between said inner and outer mandrels, means for admitting pressure fluid into said chamber, a valve operable upon relative movement between said inner and outer mandrels for controlling the admission of pressure to said chamber, and means responsive to pressure in said chamber for maintaining said cone in slip extending position.

2. In a device of the character described an inner mandrel, an outer mandrel coaxially mounted thereon, slips carried by said outer mandrel, a slip actuating cone on said inner mandrel for extending said slips outwardly of said outer mandrel, a pressure chamber formed between said inner and outer mandrels, means for admitting pressure fluid into said chamber, a valve operable upon relative movement between said inner and outer mandrels for controlling the admission of pressure to said chamber, means responsive to pressure in said chamber for maintaining said cone in slip extending position, a packer ring carried on said outer mandrel, and pressure means to expand said packer ring.

3. In a well packer an inner mandrel, an outer mandrel, slips carried by said outer mandrel, mechanical slip setting means associated with said inner mandrel, including a sleeve axially moveable relative to said outer mandrel along with said inner mandrel, said sleeve having a pressure head thereon, said head defining with said mandrels a pressure chamber therebetween, said pressure head constituting fluid pressure responsive means for retaining said slips in set position, expansible packer means on said outer mandrel, and additional pressure means for expanding said packer means independently of the setting of said slips.

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4. An apparatus as set forth in claim 3 in which the inner mandrel is hollow and fluid pressure is directed therefrom to the pressure chamber for retaining the slips in set position, and including valve means responsive to relative mandrel movement for controlling the passage of pressure fluid from said inner mandrel to said pressure chamber.

5. The apparatus as set forth in claim 3 including valve means responsive to relative mandrel movement for admitting fluid pressure to said pressure chamber for retaining the slips in set position equal to the pressure applied to the pressure means for expanding the packer means.

6. A well packer comprising an inner mandrel, an outer mandrel, a slip actuating cone slideably mounted on said inner mandrel, slips carried by said outer mandrel and engageable by said cone to be moved radially to setting position, a sleeve shiftably mounted on said inner mandrel and engaged with the cone, co-engageable portions on the inner mandrel and on the sleeve for imposing mechanical pressure from said inner mandrel on said sleeve to set said slips upon relative movement in one direction of said inner and outer mandrels, a pressure head on said sleeve, said inner and outer mandrels defining a pressure chamber at one side of said pressure head, said inner mandrel having means for admitting fluid under pressure into said pressure chamber, said sleeve having a port for venting said pressure chamber upon relative movement in the other direction of said inner and outer mandrels, packer rings carried on said outer mandrel, and pressure means to expand said packer rings.

7. A well tool of the class described comprising an inner mandrel and an outer mandrel, said mandrels being co-axially disposed with relation to one another and shiftably relatively axially, a slip actuating cone slideably mounted on said inner mandrel, slips carried by said outer mandrel and engageable by said cone to be moved radially to a set position, a sleeve shiftably mounted on said inner mandrel and engaged with the cone, co-engageable portions on the inner mandrel and on the sleeve for imposing mechanical pressure from said inner mandrel on said sleeve to set said slips upon relative movement in one direction of said inner and outer mandrels, a pressure head on said sleeve, said inner and outer mandrels defining a pressure chamber at one side of said pressure head, said inner mandrel having means for admitting fluid under pressure into said pressure chamber, and said sleeve having a port for venting said pressure chamber upon relative movement in the other direction of said inner and outer mandrels.

8. In a well tool of the class described, comprising an inner mandrel, an outer mandrel co-axially disposed about said inner mandrel, said mandrels being relatively axially moveable, laterally moveable slips carried by one of said mandrels, a cone member carried by the other mandrel for wedging the slips laterally and means for moving the cone member to a slip setting position, that improvement wherein the cone moving means comprises a sleeve moveably disposed between said mandrels, said sleeve having a fluid pressure responsive head, a shoulder projecting radially from one of said mandrels, said sleeve having a seat engageable with said shoulder, said head defining with said mandrels a pressure chamber at one side of the head when said shoulder and seat are engaged, said sleeve having a port extending through said sleeve seat for relieving the pressure chamber, means for sealing off said port when said shoulder and seat are engaged, and one of said mandrels having a port leading into said pressure chamber for the admission of pressure fluid thereto.

9. In a well tool of the class described, comprising an inner mandrel, an outer mandrel co-axially disposed about said inner mandrel, said mandrels being relatively axially moveable, laterally moveable slips carried by one of said mandrels, a cone member carried by the other

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mandrel for wedging the slips laterally and means for moving the cone member to a slip setting position, that improvement wherein the cone moving means comprises a sleeve moveably disposed between said mandrels, said sleeve having a fluid pressure responsive head, a shoulder projecting radially from one of said mandrels, said sleeve having a seat engageable with said shoulder, said head defining with said mandrels a pressure chamber at one side of the head when said shoulder and seat are engaged, said sleeve having a port extending through said sleeve seat for relieving the pressure chamber, means for sealing off said port when said shoulder and seat are engaged, one of said mandrels having a port leading into said pressure chamber for the admission of pressure fluid thereto, and co-engageable means on said inner and outer mandrels for releasably holding said mandrels in relative positions with said shoulder disengaged from said seat.

10. In a well tool of the class described, comprising an inner mandrel, an outer mandrel co-axially disposed about said inner mandrel, said mandrels being relatively axially moveable, laterally moveable slips carried by said outer mandrel, a cone member carried by the inner mandrel for wedging the slips laterally, and means for moving the cone member to a slip setting position, that improvement wherein the cone moving means comprises a sleeve moveably mounted on said inner mandrel between said mandrels, said sleeve having a fluid pressure responsive head, a shoulder projecting radially from said inner mandrel, said sleeve having a seat engageable with said shoulder, said head defining with said inner and outer mandrels a pressure chamber at one side of the head when said shoulder and seat are engaged, said sleeve having a port therethrough for relieving the pressure chamber, means for sealing off said port when said shoulder and seat are engaged, and said inner mandrel having a port leading into said pressure chamber for the admission of pressure fluid thereto.

11. A well tool for insertion in an outer casing, said tool including an inner mandrel, an outer mandrel co-axially mounted thereon, radially movable slips carried by said outer mandrel for setting the tool in such outer

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casing, a slip actuating cone on said inner mandrel for extending said slips outwardly of said outer mandrel, a pressure chamber formed between said inner and outer mandrels, said inner mandrel being provided with a port leading to said pressure chamber for the admission of pressure fluid thereto, a valve operable upon relative movement between said inner and outer mandrels for controlling the admission of said pressure to said chamber, means on the inner mandrel responsive to fluid pressure in said chamber for urging said cone in opposition to the slips to set the latter, a packer ring carried by said outer mandrel, and pressure means to expand said packer ring.

12. A well tool as defined in claim 11, wherein the fluid pressure responsive means on said inner chamber comprises a pressure head mounted on said inner mandrel, said inner mandrel also having a shoulder engaged with said cone for transmitting movement of said pressure head to said cone.

13. A well tool as defined in claim 11, wherein the fluid pressure responsive means on said inner mandrel comprises a pressure head shiftably mounted on said inner mandrel, said inner mandrel and said pressure head having co-engageable parts for effecting mechanical slip setting movement of said pressure head responsive to relative movement in one direction between said inner and outer mandrel, means extending from said pressure head towards said cone and engageable with said cone upon fluid pressure responsive movement of said pressure head in a slip setting direction, and valve means closable upon engagement of said co-engageable parts and openable responsive to disengagement of said co-engageable parts for relieving fluid pressure from said pressure chamber.

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