

Sept. 4, 1945.

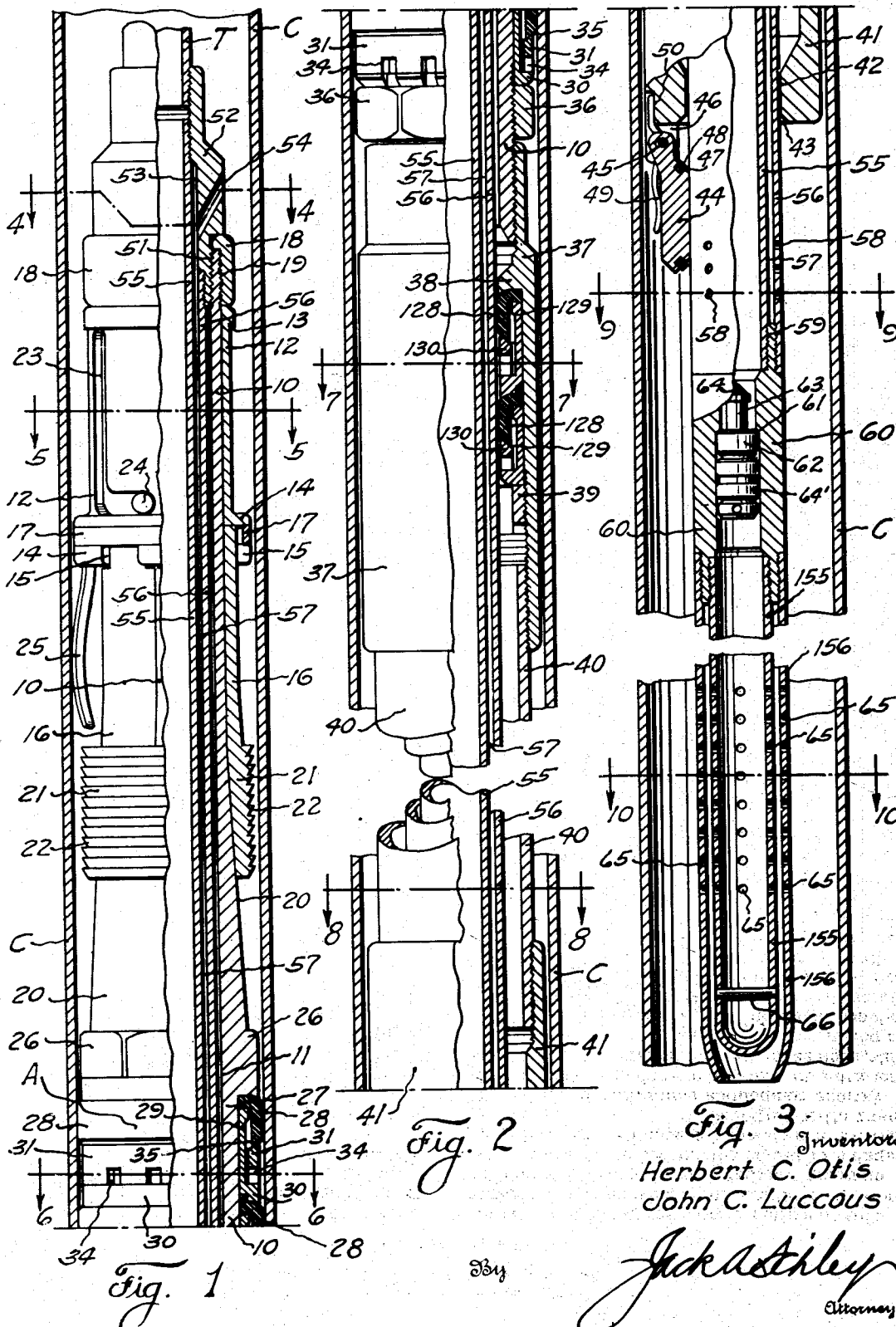
H. C. OTIS ET AL

2,384,192

WELL PACKER AND APPARATUS FOR PRODUCING WELLS

Filed Aug. 26, 1940

5 Sheets-Sheet 1



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5 Sheets-Sheet 2

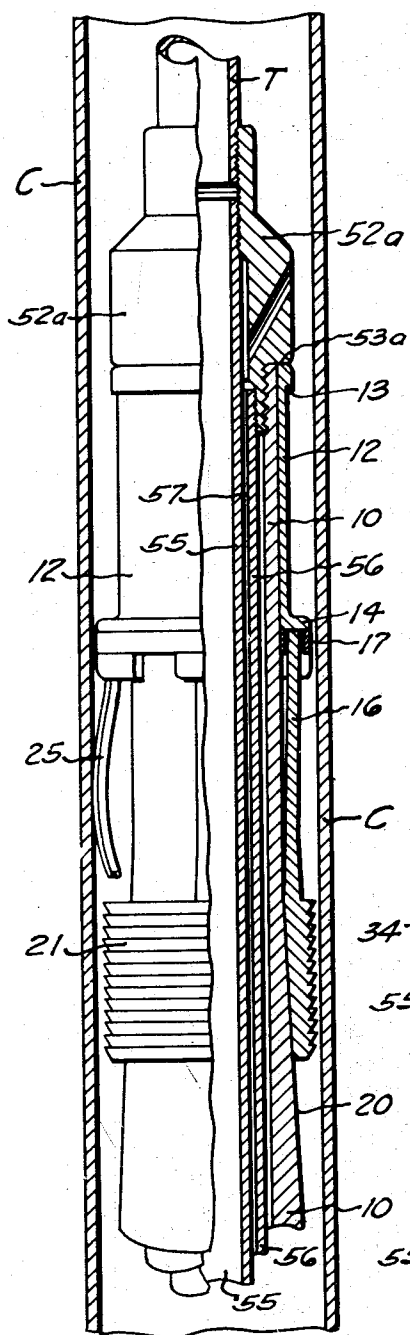


Fig. 14

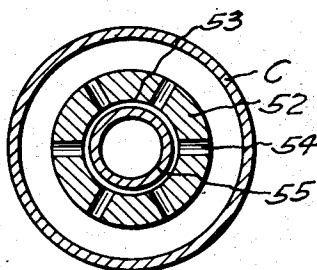


Fig. 4

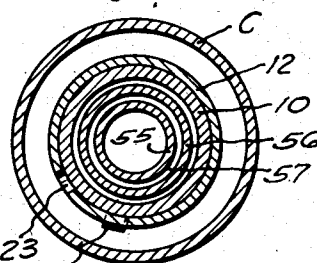


Fig. 5

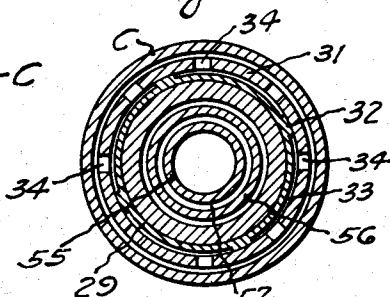


Fig. 6

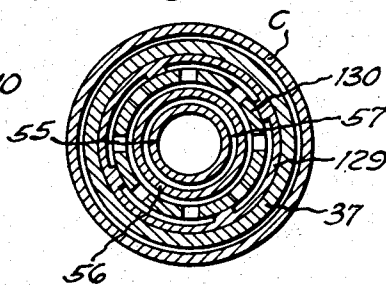


Fig. 7

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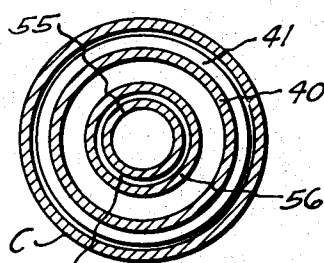


Fig. 8

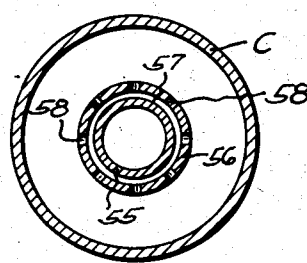


Fig. 9

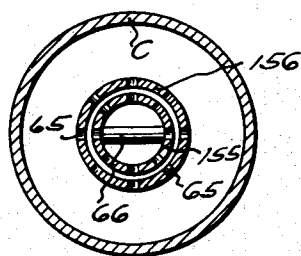


Fig. 10

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5 Sheets-Sheet 3

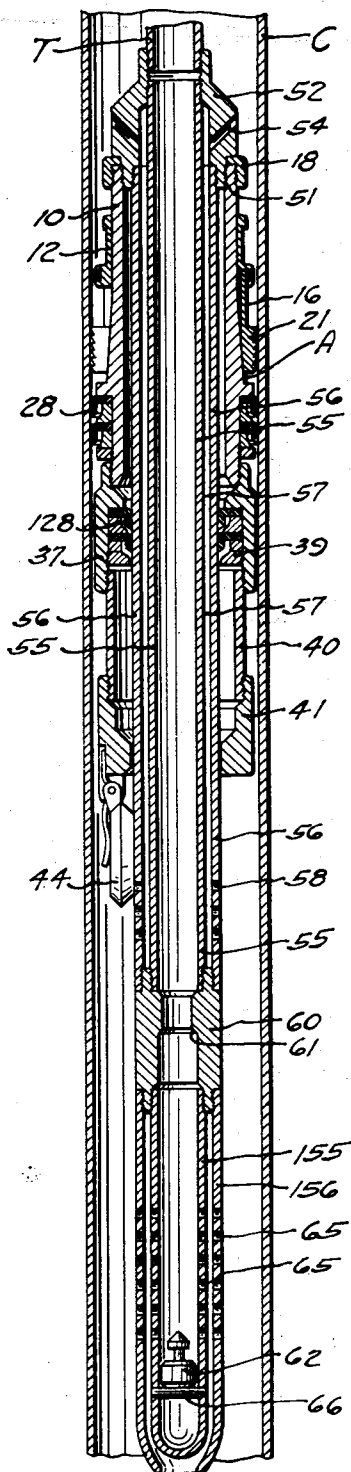


Fig. 11

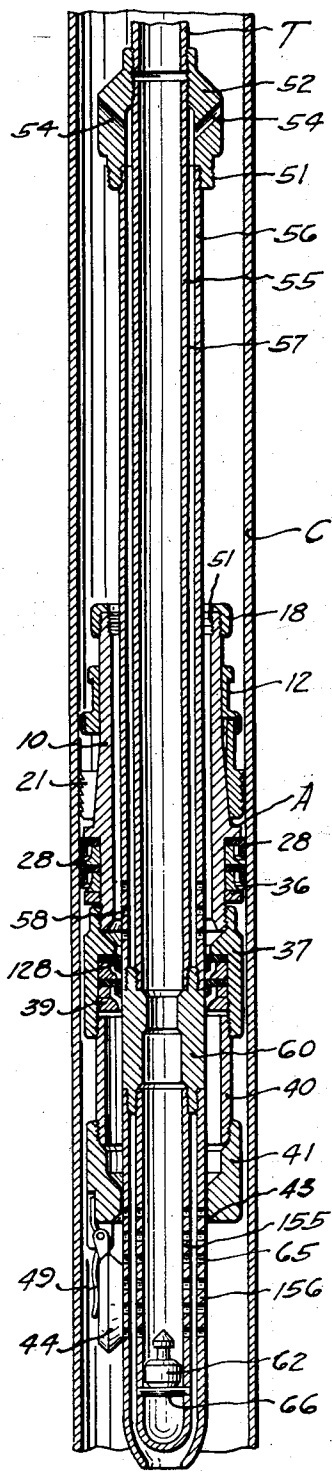


Fig. 12

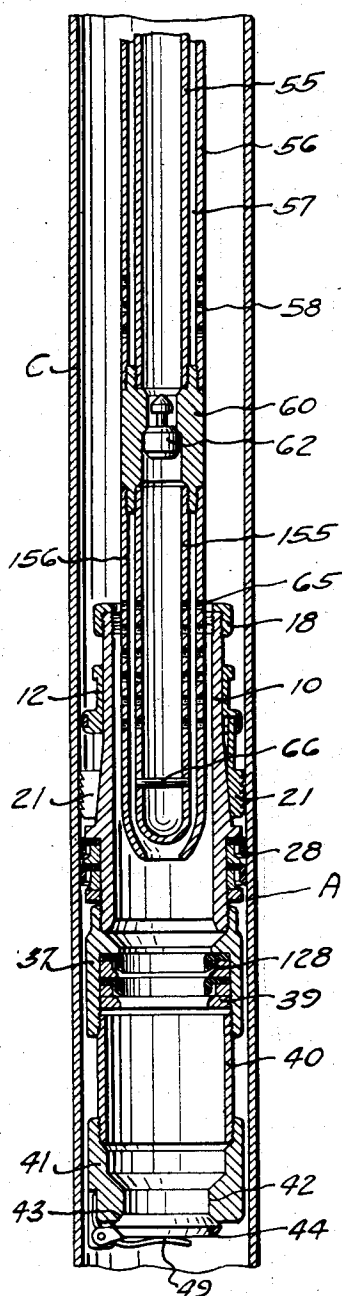


Fig. 13

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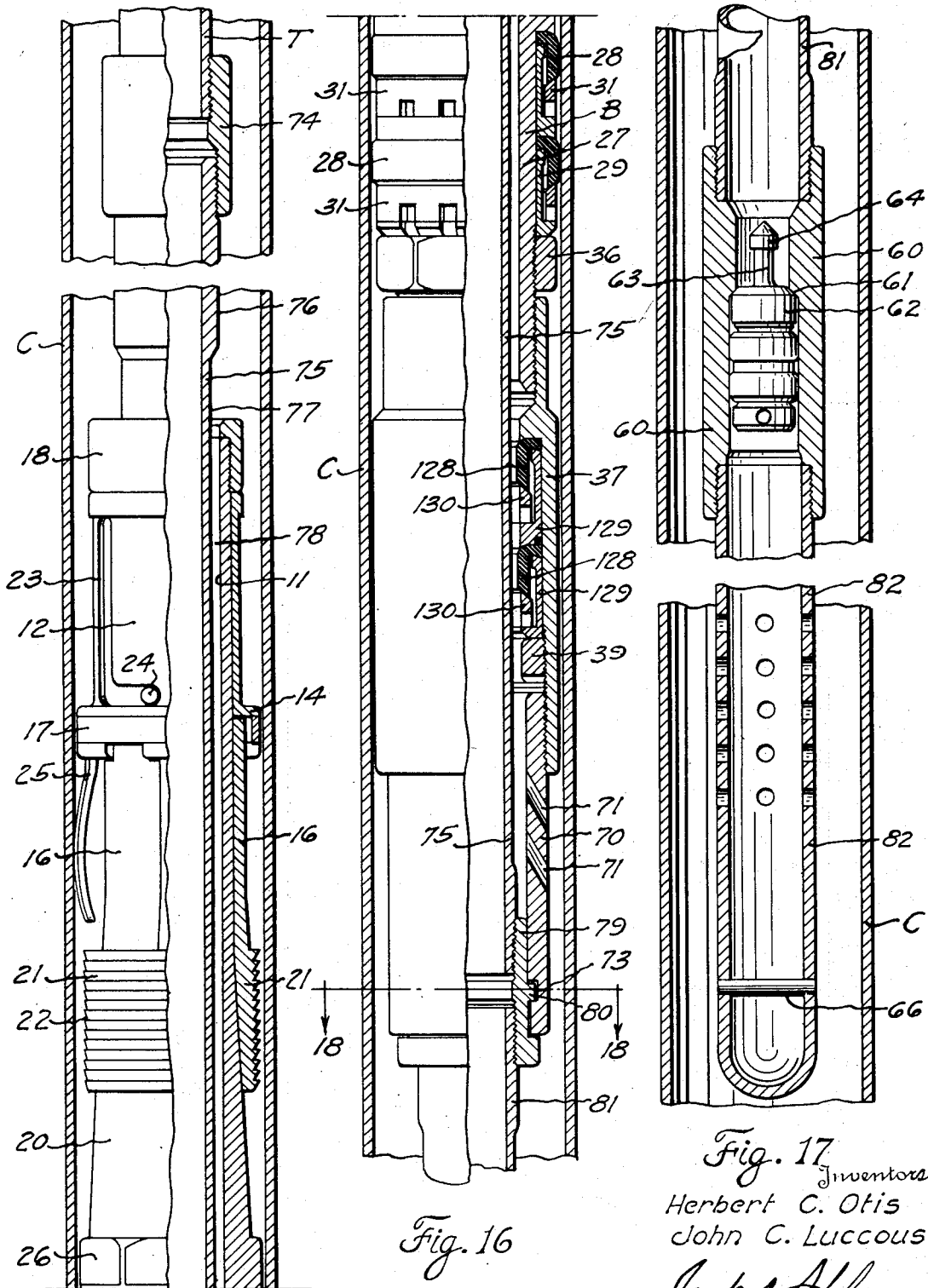


Fig. 15

Fig. 16

Fig. 17

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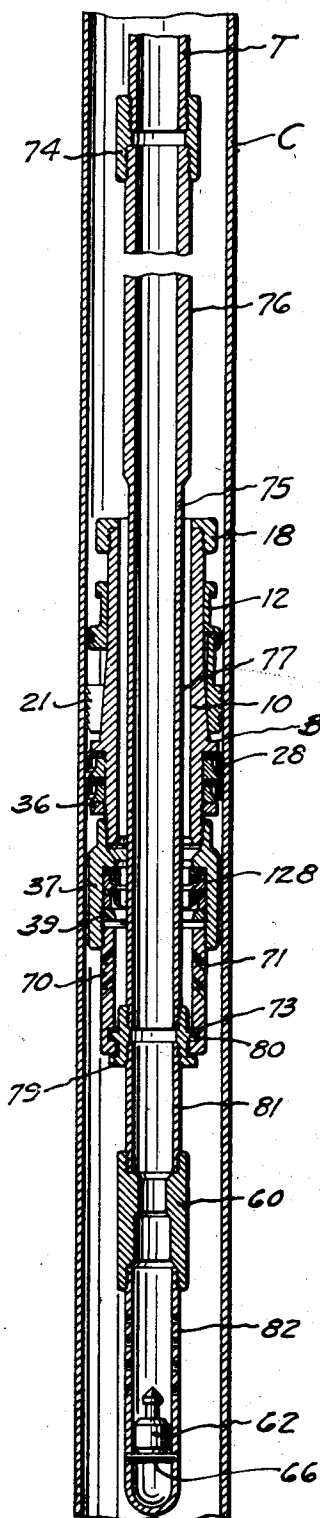


Fig. 21

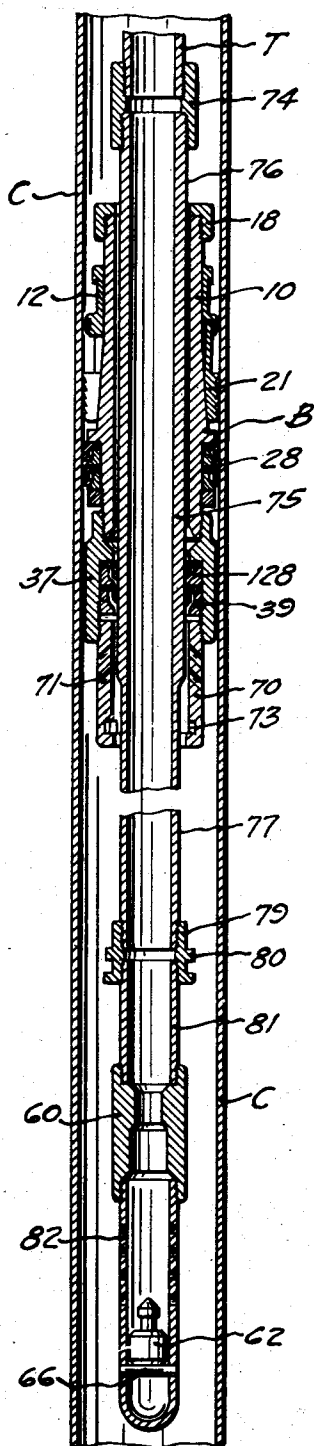


Fig. 22

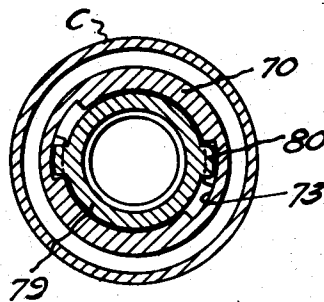


Fig. 18

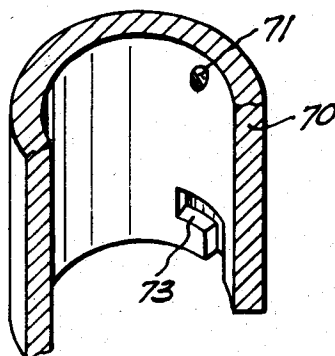


Fig. 19

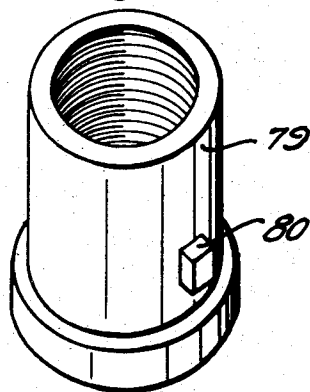


Fig. 20

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## UNITED STATES PATENT OFFICE

2,384,192

WELL PACKER AND APPARATUS FOR  
PRODUCING WELLSHerbert C. Otis and John C. Luccous, Dallas, Tex.;  
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Application August 26, 1940, Serial No. 354,172

14 Claims. (Cl. 166—2)

This invention relates to new and useful improvements in well packers and apparatus for producing wells.

One object of the invention is to provide an improved packer assembly which is particularly adapted for use in wells which have been "killed" or loaded by a mud, or other fluid column, said assembly having means for permitting a free circulation in either direction past the assembly, whereby the loading fluid column may be readily pumped from the well bore to unload the well.

An important object of the invention is to provide an improved packer assembly which may be lowered into the well bore on the production string or well tubing and which has by-pass means arranged so that there may be a free circulation of well fluid, either prior or subsequent to the setting or locking of the assembly within the well bore; the setting of the assembly before circulation is begun being particularly advantageous in that the danger of upward displacement of the assembly and production string by the well pressure after unloading of the well, is eliminated.

A particular object of the invention is to provide an improved packer assembly which is adapted to be run into the well on the well tubing and which is arranged to be set independently of the tubing, whereby the weight of said tubing is not depended upon to maintain the assembly in its sealing or packing position and also whereby the tubing is capable of longitudinal movement after the packer is set to facilitate landing of the tubing within the tubing head or support at the surface of the well; the arrangement also preventing corkscrewing or bending of the tubing and permitting bottom hole tools to be freely run through said tubing since the weight of the tubing string is not carried by the packer but rather is suspended from its support at the surface.

Still another object of the invention is to provide an improved packer assembly wherein the by-pass in said assembly may be opened or closed by a longitudinal movement of the tubing relative to the assembly, whereby closure of the by-pass is not effected by imposing the weight of the tubing on the packer assembly, as has been the practice in devices of this type.

A further object of the invention is to provide an improved packer assembly, of the character described, which is supported within the well bore by means entirely independent of the well tubing, whereby the assembly is positively locked against upward displacement by well pressure and also whereby the tubing may be re-

moved from and returned to the bore without disturbing said assembly; the packing assembly having means whereby it may be removed from the bore under pressure on a flexible line at any time after the withdrawal of the tubing string.

A still further object of the invention is to provide a device, of the character described, wherein a valve means is adapted to close the bore of the packer assembly, said valve being held open by the well tubing when said tubing extends therethrough and being automatically closed when the tubing is lifted thereabove, whereby the well tubing may be removed from, and returned to, the well bore under "dead well" conditions and without the necessity of loading the well with mud, or other fluid.

A particular object of the invention is to provide a device, of the character described, wherein improved pressure seal packing elements are employed, said elements being constructed and mounted so as to prevent "hanging up" or turning inside out during the lowering operation and also to eliminate said elements adhering or sticking to the pipe wall after having been maintained in a set or sealing position for a period of time.

Another object of the invention is to provide an improved apparatus for producing a well having a fluid column therein which includes a packer assembly run into the well on a production string, locating the packer at the point at which it is to be set, then circulating the fluid upwardly past the packer assembly to unload the well, setting the packer either before or after the circulation step, then closing the by-pass, and then producing the well fluids through the production string.

A construction designed to carry out the invention will be hereinafter described, together with other features of the invention.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings, in which an example of the invention is shown, and wherein:

Figure 1 is a view, partly in elevation and partly in section, of the upper portion of a device, constructed in accordance with the invention,

Figure 2 is a continuation of the parts shown in Figure 1 and illustrating the intermediate portion of the device,

Figure 3 is a continuation of the parts shown in Figure 2 and illustrating the lower portion of the device,

Figures 4 to 6 are horizontal, cross-sectional

views, taken on the lines 4—4, 5—5 and 6—6, respectively, of Figure 1.

Figures 7 and 8 are horizontal, cross-sectional views, taken on the lines 7—7 and 8—8, respectively, of Figure 2.

Figures 9 and 10 are horizontal, cross-sectional views, taken on the lines 9—9 and 10—10, respectively, of Figure 3.

Figure 11 is a schematic view of the complete assembly and showing the parts in the position during the circulation past the packer to accomplish unloading of the well.

Figure 12 is a similar view, illustrating the tubing disconnected from the packer assembly and showing the by-pass openings closed.

Figure 13 is a view similar to Figures 11 and 12, showing the next step with the tubing being lifted from the end of the packer assembly.

Figure 14 is a view, partly in section and partly in elevation, showing a slightly modified construction.

Figure 15 is a view similar to Figure 1, illustrating the upper portion of a modified form of the apparatus.

Figure 16 is a continuation of Figure 15, illustrating the intermediate portion of the device.

Figure 17 is a continuation of Figure 16, showing the lower portion of this form.

Figure 18 is a horizontal, cross-sectional view, taken on the line 18—18 of Figure 16.

Figure 19 is a partial isometric view of the coupling nipple at the lower end of the packer assembly.

Figure 20 is an isometric view of the coupling collar which coacts with the collar shown in Figure 19.

Figure 21 is a schematic view of the entire assembly of the modified form illustrated in Figures 15 to 20 and showing the parts in the position during circulation of the fluid which unloads the well, and

Figure 22 is a view similar to Figure 21 and illustrating the by-pass through the packer assembly closed.

In the drawings, the letter A designates a packer assembly which includes an elongate tubular mandrel 10 which has an axial bore 11 extending entirely therethrough. The upper portion of the outer surface of the mandrel is substantially cylindrical and a slip supporting carrier or sleeve 12 is slidable longitudinally on this portion. An external, annular flange is formed at the upper end of the slip carrier and has its underside bevelled inwardly to provide an undercut shoulder 13. The lower end of the slip carrier or sleeve has an enlarged collar 14 formed integral therewith and this collar has a plurality of radial T-shaped slots 15 therein, which slots are spaced equidistance therearound, and the upper ends of gripping elements 16, which upper ends are also T-shaped, are inserted within said slots. A retaining ring 17 which fits within an annular groove 18 formed in the periphery of the carrier or sleeve 12, surrounds the sleeve and prevents outward displacement of the gripping elements from the slots. Manifestly, the gripping elements are suspended from the sleeve or carrier 12 and are movable longitudinally and radially with relation to the mandrel 10. Upward displacement of the slip carrier from the mandrel 10 is prevented by means of a retaining collar 18 which is screwed onto external threads 19 which are provided at the extreme upper end of the mandrel 10.

The intermediate portion of the mandrel 10 is

flared or inclined outwardly to form a slip expanding portion 20. Each gripping element 16 includes an arcuate slip 21 at its lower end and the inner surface of each slip engages and rides upon the inclined surface 20 of the mandrel. The outer surface of each slip is formed with gripping teeth 22 which are adapted to engage the inner wall of a well casing or pipe C to prevent upward displacement or movement of the assembly, as will be explained. When the slips 21 are at the upper end of the inclined portion 20 (Figure 1), they are retracted and out of engagement with the casing wall; however, movement of the mandrel upwardly with relation to the slips causes the outward radial movement thereof to the position shown in Figures 11 to 13, whereby said slips engage the casing wall. In such position, the mandrel cannot be displaced upwardly within the casing.

The slip carrier 12 is connected to the mandrel 10 by means of an L-shaped slot 23, which is formed in the carrier, and by means of a radially extending pin or lug 24 which is secured to the mandrel and which projects into the slot. As is clearly shown in Figure 1, when the pin 24 is within the lateral or horizontal leg of the slot 23, the slip carrier 12 is in its uppermost position on the mandrel, in which position the slips 21 are retracted. When the mandrel is rotated with relation to the carrier, the pin 24 may be aligned with the vertical portion or leg of the slot 23 and when the pin is within this portion of said slot, an upward movement of the mandrel with relation to the carrier is possible. In order to frictionally retain the slip carrier 12 and the gripping element 16 against movement within the well casing C, the carrier is provided with a plurality of friction springs 25. As is clearly shown in Figure 1, each spring is secured to the enlarged collar 14 at the lower end of the slip carrier and is bowed or curved outwardly so as to frictionally engage the bore of the well casing.

Immediately below the flared or slip expanding portion 20 of the mandrel 10 there is provided an enlarged collar 26 and a reduced shank 27, the latter being formed integral with the collar and depending therefrom. A plurality of inverted, flexible packing cups or elements 28 are mounted in superposed relation on the shank 27 and the outer diameter of each cup is preferably less than the bore of the casing. As is clearly shown in Figures 1 and 2, the uppermost cup 28 abuts the underside of the collar 26 and has its outer peripheral portions spaced from the wall of the casing. A spacer sleeve 29 surrounds the shank 27 and spaces the uppermost cup 28 from the cup immediately therebelow. The spacer sleeve 29 is formed with an annular flange 30 at its lower end and a retaining ring 31 which surrounds the sleeve 29 rests upon this flange. The bore or inner surface of the ring 31 is spaced from the exterior surface of the sleeve 29 by a plurality of lugs 32 which are formed integral with the sleeve and which are clearly shown in Figure 6. The spacing of the ring 31 from the sleeve 29 provides a fluid passage 33 which has its upper end communicating with the interior of the uppermost packing cup 28. The ring 31 has a plurality of radial openings 34 in its lower portion which establish communication with the fluid passage 33 and, obviously, fluid pressure within the bore of the casing may pass through the openings 34, fluid passages 33 and into the interior of the cup 28 to expand the same into sealing engagement with the wall of the well casing. The lower end

of the packing cup 28 is bevelled inwardly as shown at 35 and this bevelled end engages a bevel which is formed on the upper end of the retaining ring 31. Manifestly, the ring 31 serves to maintain the lower end of the cup inwardly toward the mandrel and prevents said cup from turning inside out as the device is lowered through the casing. Also, in the event the cup is expanded during movement through the casing, the particular mounting of the cup assures that said cup will pass the couplings and other irregularities in the bore of the casing.

Any desired number of packing cups 28 may be employed and, between each cup, the spacer 29 and the retaining ring 31 are located. Only two cups have been shown in the drawings but any desired number may be employed. The lowermost spacer 29 of the cup assembly is engaged by a retaining nut 36 which is threaded onto the external surface of the lower end of the mandrel 10. Obviously, when the nut 36 is tightened, the packing cup assembly is confined between said nut and the enlarged collar 26 which is formed on the mandrel 10.

A tubular housing 37 has its upper end threaded onto the lower end of the mandrel 10 immediately below the retaining nut 36 and this housing forms a continuation of the mandrel 10. An internal, annular flange 38 is formed within the upper end of the bore of the housing 37 and a plurality of packing cups 128 which are similar in construction to the packing cups 28 are mounted within the bore of said housing below this flange. The cups 128 are spaced from each other by spacers 129 and are engaged by retaining rings 130, which spacers and rings are similar in construction to the rings 29 and 30 of the outside cup assembly. The cups 128 are retained in position within the bore of the housing 37 by means of a retaining nut 39 which is threaded into said bore. It is pointed out that the cups 128 are, of course, reversed with respect to the cups 28 since they are mounted within the bore of the housing, rather than on the exterior surface thereof. The cups 128 are adapted to seal off the space between the bore of the mandrel 10 and a pipe or conductor which may extend therethrough, as will be explained.

A spacing sleeve 40 which may be of any desired length and which may be formed of a section of pipe, has its upper end screwed into the lower end of the bore of the housing 37. The lower end of the spacing sleeve 40 is provided with external screw threads whereby a valve housing 41 may be threaded thereon. The valve housing 41 is substantially tubular and has the lower end of its bore reduced as shown at 42. The extreme lower end of this reduced portion of the bore is bevelled or inclined outwardly to provide an annular valve seat 43. The seat 43 is adapted to be engaged by a flap valve or disk 44 which is loosely pivoted upon a pin 45. The pin extends transversely between depending ears 46 which are formed on the lower end of the valve housing 41. The valve disk is formed with an annular seating surface 47, which is inclined or bevelled complementary to the inclination of the seat 43 and this seating surface may be provided with an elastic packing ring 48 to insure a proper seal between the valve and seat. The flap valve or disk is constantly urged toward its closed position and into engagement with the seat 43 by a spring 49. This spring has one end confined within a recess 50 formed in the external surface of the valve body 41 and said spring passes around the pivot pin 45 with its other end engaging the outer surface

of the valve. Manifestly, the flap valve is normally urged toward its seated position closing the bore of the valve housing 41.

From the foregoing, it will be apparent that the bore of the valve housing is in direct communication with the bore of the mandrel 10 through the tubular housing 37 and the spacing sleeve 40. Therefore, when the flap valve 44 is in its closed position, a flow upwardly through the bore of the mandrel 10 is prevented. Similarly, when the flap valve 44 is opened, a flow through the bore of the mandrel is permitted.

The upper end of the bore 11 of the mandrel 10 is provided with left-hand screw threads 51 and a connecting sub or coupling element 52 is adapted to be attached to the mandrel by means of these threads. As is clearly shown in Figure 1, the lower portion of the sub immediately above its external screw threads is shouldered so as to overhang the retaining nut 18 on the upper end of the mandrel. The bore 53 of the sub 52 is reduced at its upper end and this reduced portion is formed with screw threads, whereby the well tubing T may be connected to the upper end of the sub. A plurality of radially extending, inclined passages 54 are provided in the sub 52 and establish communication between the bore 53 of said sub and the interior of the well casing C. It is noted that a J-slot and pin connection may be substituted for the left-hand threads 51.

An inner conductor or pipe 55 has its upper end threaded into the upper end of the sub 52 and this conductor forms a continuation of the well tubing T; in fact, the conductor 55 may be formed by a section of the well tubing. This conductor extends downwardly through the mandrel 10, through the tubular housing 37, spacer sleeve 40 and valve housing 41 and has its lower end terminating at some distance below the flap valve 44 at the lower end of the valve housing. An outer conductor 56, which is concentric to the inner conductor 55 and which is spaced therefrom, has its upper end screw-threaded into the lower end of the bore 53 of the sub 52. The outer conductor 56 is co-extensive to the inner conductor and passes through the mandrel 10, housing 37, sleeve 40 and valve housing 41, with its lower end terminating at substantially the same plane as the inner conductor 55. Since the outer conductor 56 is spaced from the inner conductor 55, it will be obvious that an annular flow passage 57 is formed between the conductors and this flow passage has its upper end communicating with the inclined passages 54 which are formed in the sub 52. The lower portion of the outer conductor 56 is provided with a plurality of inlet ports 58 which extend through the wall of said conductor and which establish communication between the annular passage 57 and the bore of the well casing C. The ports 58, passage 57 and inclined passages 54 provide a by-pass, whereby fluid may flow from the space above the packing assembly to the space therebelow and vice versa.

The outer conductor 56 has an external diameter which is substantially the same as the internal diameter of the inner packing cups 128 which are mounted within the tubular housing 37 (Figure 2). Whenever fluid pressure is applied below the cups 128, said cups are expanded inwardly into tight sealing engagement with the exterior surface of the outer conductor 56 and, therefore, the cups 128 will serve to pack off the space between the conductor 56 and the bore 11 of the mandrel 10.

The lower ends of the inner and outer conduc-

tors 55 and 56 are connected to an upstanding nipple 59 which is formed integral with the upper end of a tubular sub or connecting element 60. An annular valve seat 61 is formed within the sub 60 and is adapted to be engaged by a valve plunger, or other closing means, 62 which is slidable within the bore of said sub. The valve plunger is formed with an extension 63 at its upper end and this extension has a suitable retrieving connection 64, whereby a suitable tool may be engaged therewith. The plunger 62 may also be provided with suitable packing elements 64' which are mounted thereon in any desired manner.

A pair of concentric conductors 155 and 156 have their upper ends connected to the lower ends of the sub 60 and may extend downwardly in the casing any desired distance. Both of these conductors are provided with perforations or openings 65, whereby a communication between the bore of the sub 60 and the bore of the well casing C is established. The inner conductor 155 is illustrated as closed at its lower end and may be provided with a transversely extending pin 66 which acts to support the valve plunger 62 when the same is dropped to its lowermost position, as will be explained. The lower end of the outer conductor 156 is open. It is pointed out that the perforations or openings 65 are disposed some distance above the transversely extending pin 66, whereby when the valve plunger 62 is in its lowermost position, said plunger is out of the line of flow entering the conductors 156 and 155, whereby the incoming well fluids will not lift the plunger to a seated position. It is noted that the inner conductor 155 may, if desired, be eliminated, in which case the transverse pin 66 would extend across the outer conductor 156.

In the operation of the apparatus and in practicing the methods to place the well in production, the parts are assembled in the position shown in Figures 1 to 3 and 11. In such position, the well tubing T is connected to the upper end of the mandrel 10 of the packer assembly by means of the left-hand threads 51, whereby the inner and outer conductors 55 and 56 extend downwardly through the packer assembly and hold the flap valve or disk 44 in an open position. Also, the slip carrier 12 is coupled to the mandrel 10 through the pin 24 and slot 23, said pin being in the lateral or horizontal portion of said slot, whereby the carrier is held against movement at the upper end of the mandrel. In this position, the slips 21 are held in a retracted position. As the well tubing is lowered through the well casing C, the packer assembly carried by said tubing is lowered therewith. At this time, the exterior packing cups 28 are, of course, in a retracted position since any pressure within the well casing is equalized across the device. The assembly is particularly adapted to be lowered through a well casing which is loaded or which has a column of mud or other fluid therein, but may be used equally well in wells which are not so loaded. When the desired depth at which the packer assembly is to be set has been reached, the tubing T is rotated so as to move the pin 24 on the mandrel into alignment with the vertical portion of the slot 23 in the slip carrier 12. The tubing and mandrel are then raised upwardly with relation to the slip carrier, such upward movement being permitted because the pin 24 moves upwardly through the vertical portion of the slot 23. During such upward movement of

the mandrel, the slip carrier, together with the slips mounted thereon are held substantially stationary by the friction springs 25 which engage the wall of the well casing.

As the mandrel 10 is moved upwardly with relation to the slips 21, the flared or slip expanding portion 20 of said mandrel is moved upwardly between the slips 21 and acts to move said slips radially outwardly into engagement with the wall of the well casing C. Upon such engagement, the slips serve to prevent upward displacement of the packer assembly within the well casing.

It is noted that during the lowering of the assembly through the well casing, the valve plunger or closing tool 62 which is mounted within the sub 60 is engaging its seat 61, being held so by the pressure exerted against the bottom of said plunger, as the tubing moves downwardly in the casing. Therefore, while the apparatus is being lowered through the well casing, the bore of the conductor 55 and tubing T is closed. After the packer has been set as described, a pressure fluid is pumped downwardly through the tubing and such fluid passes downwardly through the inner conductor 55, acting to force the valve plunger 62 downwardly from the sub 60 and into the inner conductor 155, whereby said valve plunger comes to rest on the transverse supporting pin 66. In such position, the valve plunger 62 is out of the line of flow, since it is below the perforations 65 in the tubes 155 and 156. If desired, any other means may be employed for unseating the plunger.

After the valve plunger 62 has been moved downwardly onto the transverse supporting pin 66, as shown in Figure 11, the mud or other fluid which is within the well casing may be unloaded from said casing either by continuing to pump downwardly through the well tubing T and into the casing or by reversing the circulation at the surface through the usual reverse circulation apparatus (not shown) and pumping downwardly through the casing. If the pumping is continued so as to force the pressure fluid downwardly through the well tubing T, such fluid flows outwardly through the ports 65 in the conductors 155 and 156 and then upwardly through the well casing. The pressure applied through the tubing in this manner will force the fluid within the well casing upwardly through the by-pass ports 58, annular passage 57 and inclined passages 54 in the sub, whereby said fluid is lifted upwardly through the casing and said casing is thereby unloaded. If the pressure fluid is pumped downwardly through the casing C, the fluid within said casing is forced downwardly through the by-pass in the packer assembly and is then forced through the ports 65 and upwardly through the tubing. So far as the present invention is concerned, the circulation may be in either direction through the packer assembly and in either case, the well casing may be successfully unloaded.

As above described, the gripping slips 21 have been set prior to the circulation which effects the unloading of the casing C, but it is pointed out that in some instances, said slips need not be set until after the circulating operation is complete and the well casing is clean. Of course, it is apparent that as a safety measure, it is more desirable to set the slips prior to circulation so that in the event that the well pressure is sufficient to lift the assembly, upward displacement will be prevented.

After the mud or other heavy loading fluid

within the well casing has been circulated out of said casing, whereby natural flow of the well is permitted, the connecting sub 52 which is normally connected to the upper end of the mandrel is disconnected from said mandrel by rotating the tubing and the sub to the right. Due to the left-hand threads 51, such rotation to the right will cause the sub 52 to be unscrewed from the mandrel, whereby after such disconnection, the tubing, sub 52 and conductors 55 and 56 may be raised with relation to the mandrel which is locked within the casing by the slips, as explained. It is pointed out that, if desired, the left-hand threads may be disconnected prior to the circulation, the tubing string being supported in substantially the same position relative to the packer as shown in Figure 11. The disconnection prior to circulation obviates the necessity of disconnecting under high pressure in the event such pressure exists in the well bore. After the sub is disconnected, the tubing is raised upwardly until the by-pass ports 58 at the lower end of the outer conductor 56 are disposed above the inner packing cups 128, as is clearly shown in Figure 12. As soon as the by-pass openings 58 move above the cups 128, the communication between the annular by-pass 57 and the interior of the casing is shut off. After this is done, the flow of fluid from the well casing below the packer assembly cannot pass upwardly into the casing above said packer. The well fluids which enter the lower end of the casing from the producing formation will exert their pressure upwardly against the assembly and will tend to urge the mandrel upwardly relative to the slips 22, whereby this pressure will aid in holding the assembly in its set or locked position. Also, this pressure fluid will pass upwardly and will enter the space behind the packing cups 128 and also the packing cups 28, whereby said cups are moved into and held in a positive sealing position. It might be desirable to circulate fluid downwardly through the tubing immediately after the parts have been moved to the position shown in Figure 12 and, in such instance, the pressure fluid passing outwardly into the casing through the ports 65 in the conductors 155 and 156 will pass upwardly and be exerted against the packing cups 128 and also against the packing cups 28. In this case, the packing cups may be actually set or moved to their sealing position by a pump pressure from the surface. Likewise, the seal obtained by the cups may be checked by testing the pressure in the annular space between the tubing and the casing below the packing assembly. After the parts have moved to the position shown in Figure 12 and the packing cups have been set or moved to a sealing position, the surface connections are made up and the well may be opened for flow. Such flow will of course enter the ports 65 in the lower ends of the conductors 155 and 156 and will flow upwardly through the well tubing or production string T. It is pointed out that since the tubing may be raised or lowered through the packer, such movement facilitates the landing of the tubing in the tubing head or support at the surface, since no extremely accurate fit is required because the weight of the tubing is not carried on the packer. It is also pointed out that the packer is independently supported or locked within the tubing and does not depend upon the weight of the tubing for holding said packer in its sealing position. Further, the by-pass passage through the packer is closed without putting the weight of the tubing string on the packer, since a sliding valve arrangement is in effect provided.

It may, under some conditions, become desirable or necessary to pull or remove the tubing string T from the well and, in such instance, it is only necessary to remove the surface tubing connections and raise said tubing. Prior to the raising of the tubing, a suitable tool, such as illustrated in Otis Patent No. 1,898,261, may be run downwardly through said tubing and said tool engaged with the valve plunger 62 so as to lift said plunger upwardly into engagement with the seat 61 and thereby close the bore of the well. Instead of lifting the plunger 62, a suitable wire line plug may be run downwardly into the tubing and set therein so as to close the bore of said tubing. When the tubing is lifted upwardly, the lower end of the conductors 155 and 156 will enter the bore of the valve housing 41 and as soon as this occurs, the spring 49 will immediately move the valve disk 44 to a closed position into engagement with its seat 43, whereby the bore of the mandrel 10 is closed. It is pointed out that the length of the spacing sleeve 40 is such that the inner packing cups 128 maintain a seal around the tubing string until such time as the valve disk 44 moves to a closed position and, in this way, the well pressure is held under control at all times and the well fluid cannot pass upwardly around the tubing string. After the flap valve 44 has been closed, the well fluid is trapped below the packer assembly and thus the tubing may be withdrawn from the well under "dead well" conditions just as if the well were loaded with mud or other fluid. Thus, the packer assembly is utilized to automatically close the bore of the well casing when the tubing is moved upwardly therethrough.

The tubing may be re-run into the well at any time and, upon its return, the lower rounded end of the conductor 156 will engage the valve disk 44 and will move the same to its open position. Downward movement of the tubing is continued until the parts again assume the position shown in Figure 11, at which time flow of the well fluid to the surface may again occur. Therefore, it will be seen that the arrangement permits the removal and return of the well tubing under "dead well" conditions, since the well pressure is trapped below the packer until the flap valve or disk 44 is open.

When the well tubing T is removed from the well, as above described, the packer assembly remains locked within the well casing C and acts as a plug to prevent upward flow. If it is desired to remove the packer assembly, it is only necessary to lower a suitable retrieving tool (not shown), which tool may be run downwardly through the casing on a flexible line. The retrieving tool is utilized to engage the undercut shoulder 13 at the upper end of the slip carrier 12 and is also employed to jar downwardly on the mandrel 10. Such jarring downwardly of the mandrel will cause said mandrel to move downwardly with relation to the slips 22 and thereby permit the slips to move inwardly on the inclined portion of said mandrel. After the slips are disengaged, an upward pull on the tool will result in an upward movement of the slip carrier 12 relative to the mandrel until said carrier strikes the collar 18 at the upper end of the mandrel. After this occurs, a continued upward movement will result in a withdrawal of the entire assembly from the well casing.

The apparatus is relatively simple in construction and is positive in its operation. Upon initial lowering into the well casing, the packer assembly is connected to the well tubing by means of the sub 52 which is engaged with the left-hand

threads 51. With the parts in the position shown in Figure 11, the by-pass 57 is open and a free circulation of fluid past the packer assembly is possible, whereby the well may be readily unloaded. After the well is unloaded, the tubing is disconnected from the packer assembly and is moved upwardly a sufficient distance to close the by-pass ports 58 by moving said ports above the inner packing cups 128, as shown in Figure 12. In such position, normal production of well fluid upwardly through the well tubing or production string T may occur. The parts remain in such position until it is desired to remove the tubing and when said tubing is to be removed, it is only necessary to pull the same upwardly and such upward movement will permit an automatic closing of the flap valve or disk 44 to shut the well in. The packer assembly does not depend upon the weight of the tubing to hold it in its set position and obviously, when in such position neither the packer or tubing exert a force upon each other, each being independent of the other.

It is pointed out that as above described, the circulation to unload the well is performed while the parts are in the position shown in Figure 11 and prior to the disconnection of the tubing from the packer assembly. If desired, before the beginning of circulation, the tubing T may be disconnected from the packer assembly by unscrewing the sub 52 from the mandrel. After such disconnection, the tubing is raised upwardly so that the lower ends of the conductors 155 and 156 are above the packer assembly. Obviously, the flap valve 44 would of course close as soon as the tubing is lifted thereabove. After the parts are in such position, a pump pressure may be applied to the tubing and fluid forced outwardly through the ports 65 and into the casing above the packer assembly, whereby the mud or other fluid within the well casing will be lifted to the surface. In this manner, unloading of that portion of the casing above the assembly may be performed as the first circulating step and after this portion of the casing is unloaded, the tubing is then moved downwardly through the packer assembly until the by-pass ports 58 are below the packing cups 128. If necessary, a continued circulation may be effected to unload any fluid which may be standing in the casing below the packer assembly. Thus, it will be seen that the circulation to unload the well may be performed in two steps, rather than in a single operation as has been described. It may be desirable in running the apparatus into the well to employ a tubing catcher (not shown), which catcher would preferably be mounted in the tubing string below the packer assembly. For example, the catcher could be connected between the lower ends of the inner and outer conductors 55 and 56 and the sub 60. If desired, the tubing catcher could be located in the tubing T above the sub 52. The provision of such a tubing catcher would prevent the tubing and packer assembly from falling to the bottom of the well bore in the event that the tubing should part while in the casing.

In the form of the invention hereinbefore described and illustrated in Figures 1 to 13, the slip carrier 12 is illustrated as having connection with the mandrel 10 through the pin 24 and slot 23. It is pointed out that this slot and pin connection may be eliminated and, in Figure 14, such a construction is shown. In this form, the exterior surface of the upper end of the mandrel 10 is free from the screw threads 19 as the collar 18 is eliminated. The sub 52a is substituted for the

sub 52 and is substantially identical in construction, being provided with an overhanging shoulder 53a which overlies the upper end of the slip carrier. The device is set in exactly the same manner as has been described with reference to the first form, that is, an upward movement of the mandrel 10 is accomplished while the slip carrier is held stationary by the friction springs 25. In removing the slip assembly from the well casing C, the sub 52a is first disconnected and the tubing is removed from the well. A suitable retrieving tool and jars associated therewith are then lowered into the well casing on a wire line and the tool is engaged with the undercut shoulder 13 on the slip carrier. A jarring downwardly on the mandrel releases the slips and an upward pull on the carrier by means of said tool (not shown) will remove the slip carrier and the slips from the well, independently of the mandrel 10, which mandrel will remain in the well casing. After the slip carrier and its slips have been removed, a suitable pulling tool such as an overshot (not shown) is lowered into the well and the upper end of the mandrel is grasped thereby. An upward movement of the overshot will thus remove the mandrel and its associate parts from the well casing. It is apparent that this form of the invention is substantially identical with the other form, with the exception that the pin and slot connection is eliminated.

In the forms of the invention hereinbefore described, the well tubing string is removable independently of the packer assembly. However, in some instances, it might not be necessary to provide for removal of the tubing string separately or independently from the packer assembly and, in such case, the construction shown in Figures 15 to 22 may be employed. In this modification of the invention, a packer assembly B which is similar in construction to the packer assembly A is employed. The packer assembly B is not provided with the left-hand screw threads 51 at the upper end of its mandrel; neither is the assembly B provided with the spacing sleeve 40 and the valve 44 at its lower end. In place of the sleeve 40, a tubular nipple 70 is threaded into the lower end of the mandrel below the inner sealing cups. This nipple is provided with a plurality of inclined by-pass ports 71, which are comparable to the by-pass ports 58 in the first form. A pair of diametrically opposed, angular recesses 73 are formed at the lower end of the nipple, as is clearly shown in Figure 19.

The lower end of the well tubing T is connected by means of a coupling collar 74 with an elongate tubular conductor 75. The upper portion of the conductor 75 has its external diameter enlarged as shown at 76 and this diameter is substantially equal to the internal diameter of the inner packing cups 128. Below the enlarged portion 76, the conductor 75 is reduced in diameter at 77, whereby the outer surface of this portion is spaced from the wall of the bore 11, such spacing providing an annular by-pass 78 when the parts are in the position shown in Figures 15 and 21. The lower end of the conductor 75 has a coupling collar 79 connected thereto and this collar is formed with outwardly extending lugs 80 which are adapted to coact with the angular recesses 73 in the nipple 70 to effect a connection of the tubing with the packer assembly. Below the collar 79, a conductor 81 is provided and this conductor has the sub 60 connected to its lower end. The closure or valve plunger 62

is normally seated within the sub 60 and below said sub a perforated section of pipe 82 is provided and this section may have the transverse supporting pin 66 disposed at its lower end.

In the operation of this form of the invention, the coupling collar 79 is coupled to the nipple 70 at the lower end of the packer assembly by the engagement of the lugs 80 within the lateral or horizontal portions of the recesses 73. In such position, the reduced portion 77 of the conductor 75 is extending through the bore of the mandrel 10, and is spaced therefrom, whereby the annular flow passage 78 is formed. This flow passage has its lower end communicating with the by-pass ports 71, while its upper end communicates with the bore of the casing above the assembly B. At this time, the gripping slips 21 are held in a retracted position due to the pin 24 on the mandrel being disposed within the lateral portion of the angular slot 23.

After the assembly is lowered to the proper position, the tubing T is rotated to move the lugs 80 into alignment with the vertical portions of the recesses 73 and then to impart a rotation to the mandrel through the coupling elements 79 and 70, whereby the pin 24 on the mandrel is moved into alignment with the vertical portion of the slot 23 in the slip carrier 12. After this is done, an upward movement of the tubing and mandrel will result in a setting of the slips, as has been explained. After the slips are set, pump pressure may be applied to the upper end of the tubing or to the upper end of the casing to set up a circulation which will result in an unloading of the mud or other fluid within the well casing C. This circulation is permitted through the by-pass ports 71 and the annular flow passages 78.

When the unloading of the well is complete, the tubing T is moved downwardly with relation to the packer assembly B, such movement being possible since the lugs 80 have been aligned with the vertical portions of the recesses 73. The tubing is moved downwardly to the position shown in Figure 22, whereby the enlarged portion 76 of the conductor 75 is moved into engagement with the inner packing cups 128. Such engagement of the packing cups with the enlarged portion 76 serves to seal off the space between the exterior of the tubing string and the bore of the mandrel, whereby the by-pass through the packer assembly is closed. Thus, the production of the well fluid may occur in the same manner as has been described with reference to the first form, that is, upwardly through the tubing or production string T.

When it is desired to remove the apparatus from the well casing, it is only necessary to raise the tubing so as to recouple the collar 79 with the nipple 70. When this is done, the mandrel 10 may be moved downwardly so as to move the pin 24 thereon into the horizontal portion of the slot 23 in the slip carrier 12. In such position, the slips 21 are retracted and the entire device may be removed from the well casing. This form of the invention operates in substantially the same manner as has been described with reference to the forms shown in Figures 1 to 13, the only difference being that the tubing string is not removable independently of the packer assembly.

The foregoing description of the invention is explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction, may be made, within the scope of the appended claims, with-

out departing from the spirit of the invention.

What we claim and desire to secure by Letters Patent is:

1. A well packer apparatus including, a packer having means for anchoring it in a well, a well tubing member extending through and detachably connected to the packer and movable longitudinally relative to the packer when the packer is anchored and the tubing member is detached therefrom, the packer having a fluid by-pass therethrough exteriorly of the bore of the tubing member open when the tubing member is attached to the packer, and means carried by the packer coacting and engageable with the tubing member to shut off the by-pass when the tubing member is detached from and moved longitudinally of the packer past said means, said tubing member being further longitudinally movable relative to the packer after the by-pass is shut off.
2. A well packer apparatus as set forth in claim 1, and gravity actuated means in the tubing member for closing the bore thereof against an upward flow of fluid therethrough adapted to be opened when the apparatus is lowered to a predetermined position in a well.
3. A well packer apparatus as set forth in claim 1, wherein the packer anchoring means is detachably connected with the packer and may be set when detached; said anchoring means being retractable when detached to permit upward withdrawal of the packer.
4. A well packer apparatus including, a packer having means for anchoring it in a well and provided with a fluid by-pass passage therethrough, a tubing member extending through the packer passage and detachably connected to the packer, the by-pass passage being open when the tubing member is attached to the packer, an enlarged portion on the tubing member positioned to enter the by-pass passage when the member is detached from the packer and moved longitudinally, and means in the passage of the packer engaged by and coacting with the enlarged portion of the tubing member when the latter is moved into said passage to shut off fluid flow through said passage.
5. A well apparatus including, a tubular packer provided with a passage therethrough and having means for anchoring it in a well, packing exposed in the passage of the packer, a tubing member initially extending through the packer and detachably connected therewith for relative independent longitudinal movement when detached therefrom, the tubing member having a fluid by-pass portion open when the tubular member is connected to the packer to by-pass fluid around the packer and also having another portion engaging with the exposed packing within the packer when the tubing member is detached from and moved longitudinally of the packer to close off the by-pass portion to upward flow of fluid from below the packer, said tubing member also having a fluid flow opening at its lower end portion.
6. The combination set forth in claim 5, with an internal valve seat in the tubing member above the fluid flow opening thereof, a valve support below said flow opening, and a valve movable in the tubing member between said seat and said support adapted to respond to upward fluid pressure and engage said seat and to fall to said support when fluid pressure is relieved.
7. A well apparatus including, a packer having means for anchoring it in a well, a well tub-

ing member adapted to be connected to a well tubing and extending through and detachably connected with the packer, said member being movable longitudinally through the packer when detached therefrom, the tubing member having a fluid by-pass portion extending through the packer to by-pass fluid around the packer when the tubing member is attached thereto, and means carried by the packer and coacting and engaging with the tubing member for shutting off the by-pass through the packer when the tubing is detached from and moved longitudinally of the packer a predetermined distance while the packer is anchored, the weight of the tubing member and the tubing being taken off the anchored packer when the tubing member is detached therefrom.

8. A well apparatus including, a tubular packer adapted to be lowered within a well and having a flexible sealing element on its exterior surface for sealing the space between the packer and the wall of the well and also having an elastic sealing element within its bore, means for supporting said packer within the well, a well tubing string movable longitudinally through the packer, said tubing string extending through the packer and having an inlet in its lower portion in communication with the well bore below the packer, and a conductor surrounding the lower portion of the tubing above the inlet and extending through the packer and engaged by the inner elastic sealing element which packs off therearound, the space between the conductor and tubing forming a by-pass passage through the packer, means establishing communication between the by-pass passage and the well bore above the packer, the conductor having an opening therein for establishing communication between the by-pass passage and the well bore below the packer when said opening is below the inner sealing element, whereby fluid may by-pass the packer, upward movement of the tubing and conductor relative to the packer moving the said opening above said sealing element to close the by-pass and prevent flow therethrough.

9. A well apparatus including, a packer provided with a passage therethrough and having means for anchoring it in a well, a packing exposed in the passage of the packer, and a tubing member slidable longitudinally through the packer passage and the packing thereof, said tubing member having a longitudinal bore for the flow of fluid therethrough and a flow opening at its lower end, said tubing member also having a separate longitudinal fluid passage exterior of the bore provided with flow openings at each end exterior of the bore, the member being packed off by the packing and movable longitudinally to position its fluid passage openings above and below the packing and also being movable longitudinally to position both of its passage openings above the packing.

10. A well apparatus as set forth in claim 9, with a valve seat in the bore of the tubing member above the fluid opening of said bore, and a gravity actuated valve movable in the bore of the member engaging said seat.

11. A well packer assembly including, a packer having means for anchoring it in a well, a well tubing member movable longitudinally through

the packer, means providing a by-pass between the tubing member and the packer for the passage of fluid around the latter, and means carried by the packer and coacting with the tubing member for shutting off the by-pass when the tubing is moved longitudinally of the packer in one direction, the tubing member being movable longitudinally within the packer while the by-pass is shut off and while coacting with the shut off means, and said tubing being entirely removable from the packer.

12. A well packer apparatus including, a packer body having a fluid passage therethrough, retractable anchoring means mounted on the packer body, fluid responsive packing mounted externally on the packer body, a tubing member extending through the packer body, said packer body and said tubing member being formed to provide a fluid by-pass therebetween, means for detachably connecting the tubing member with the packer, whereby the by-pass passage is initially held open, and means carried by the packer and the tubing member coacting to close off the by-pass passage when the tubing member is detached from the packer and moved longitudinally thereof, the tubing member being also further movable longitudinally with respect to the packer when the by-pass passage is closed.

13. A well packer apparatus including, a packer body having a passage therethrough, external packing on the body, a slip expanding portion on the body, a slip carrier on the body having slips engaging the expanding portion thereof, a tubing member adapted to be connected with a tubing string and extending through the body, means for detachably connecting the tubing member to the packer, whereby the tubing member may be moved longitudinally in the packer-body passage when detached from said body, the tubing member having a fluid by-pass portion open to the exterior of the member at each end and positioned to by-pass fluid relatively through the packer body when said member is attached to said body, and packing means in the passage of the body coacting with the tubing member to close the by-pass portion to fluid flow when said member is detached and moved longitudinally.

14. A well packer apparatus including, a packer member, anchoring means mounted on the packer member, packing mounted externally on the packer member, a tubing member extending through the packer member, said packer member being formed to provide a fluid by-pass passage externally of the tubing member, means for detachably connecting the tubing member and the packer member whereby said by-pass passage is open when said members are connected together, and means carried by one of said members and engageable with the other of said members to close said by-pass passage when said members are detached and moved relative to each other in a longitudinal direction, said members being also further movable longitudinally a predetermined distance with respect to each other after the by-pass passage is closed, without affecting the last-named condition of the by-pass passage.

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